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Sub-Railroad Cold Storage

ELECTRICALLY DRIVEN REFRIGERATING MACHINERY AND COLD STORAGE WAREHOUSE LOCATED UNDER FREIGHT TERMINAL TRACKS

IT IS NOT ALWAYS POSSIBLE to locate a cold storage plant in the most desirable place in a large city, nor do city governments in their demands upon railroad companies always consider what effects their ordinances will have upon the industry of the community. Accepting conditions as they are found, conforming them to meet successfully the needs of the community, is the work of the business man and the engineer and is well exemplified in a cold storage plant recently put into operation under freight terminal tracks.

Along the west bank of the south branch of the Chicago River is a net work of railroad tracks which has been one of the principal sources of attack for those who are making plans for a City Beautiful. Over a section of these tracks, city authorities have permitted the railroad companies to build viaducts at street crossings, but further back from the river tracks must be elevated to allow traffic to pass under.

To elevate a whole quarter section of terminal tracks some 20 ft., which was the problem at the Soo Terminal in Chicago, entailed a great expense. The work had to be done, however, and apparently little thought was given at the time as to what use could be made of the space under the tracks. Later, somebody conceived the idea of walling in this large area and converting the space into warehouses. This was done and the appearance of the place greatly improved, conforming quite closely to the City Beautiful plans.

After a large section of this space had remained idle for some 2 yr., following the completion of the building, the possibilities of the location were called to the attention of the Chicago Cold Storage Warehouse Co., which

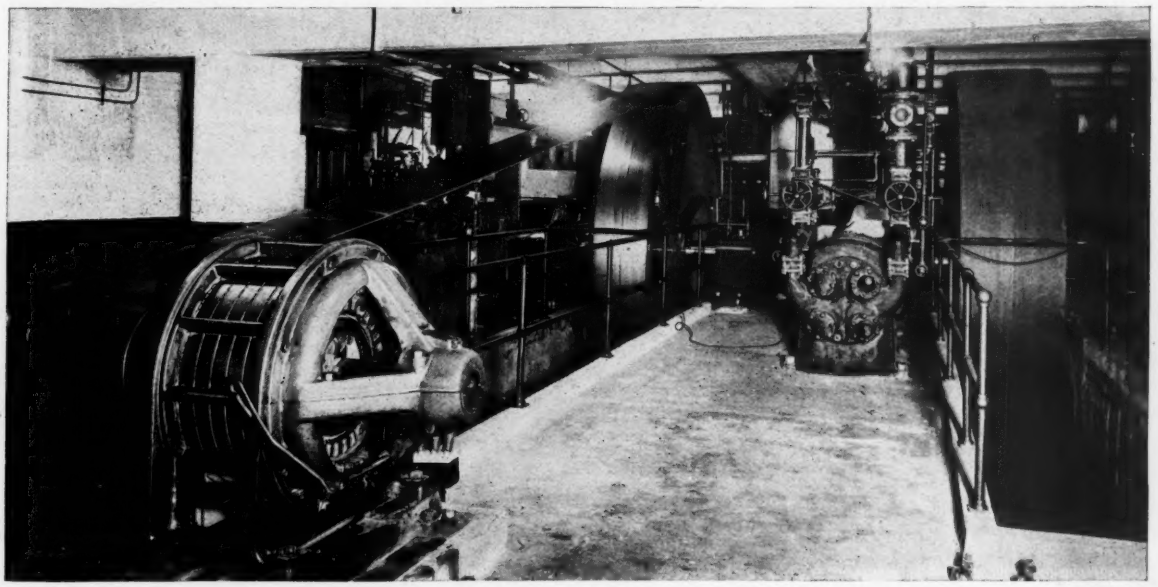


FIG. 2. PRESENT INSTALLATION OF MOTOR DRIVEN AMMONIA COMPRESSORS

secured a long lease for practically 3 city blocks of this area and is now converting the space into 3 cold storage warehouses, designated by the company as C, D and E.

Transportation facilities here are ideal. Overhead are all the switch tracks of the Soo Terminal, from which elevation industrial cars are lowered to the warehouse floor by electrically driven hydraulic elevators, one being provided for each warehouse except E, while one railway track serves houses D and E direct, extending through the center the entire length of the 2 buildings with loading platforms on both sides. In house D there is space for 10 cars, while in E, 15 cars can be accommodated. The company does a general cold storage business in these houses to accommodate all customers; the principal products stored, however, are meats, poultry, fish, oysters, apples and eggs. When completed the entire space under low temperature control will be 5,500,000 cu. ft.

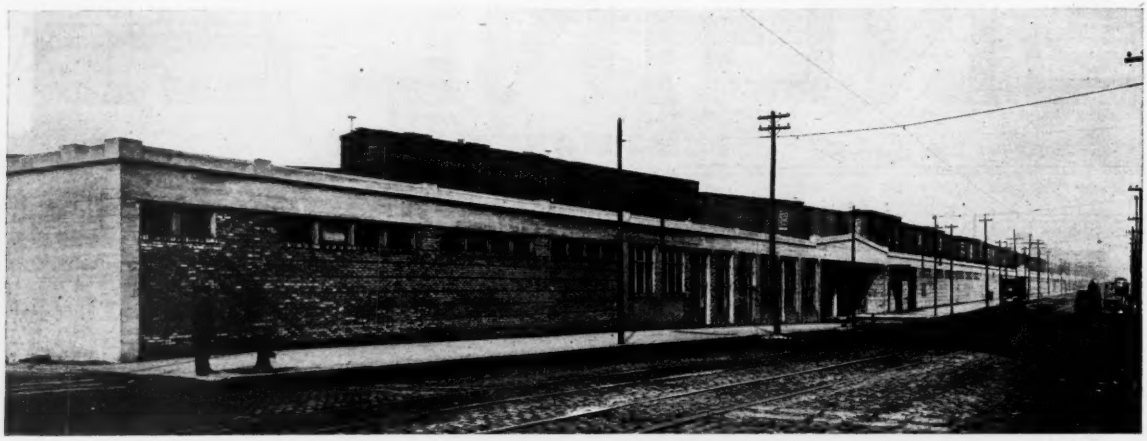


FIG. 1. VIEW OF CHICAGO COLD STORAGE WAREHOUSE CO.'S NEW PLANT

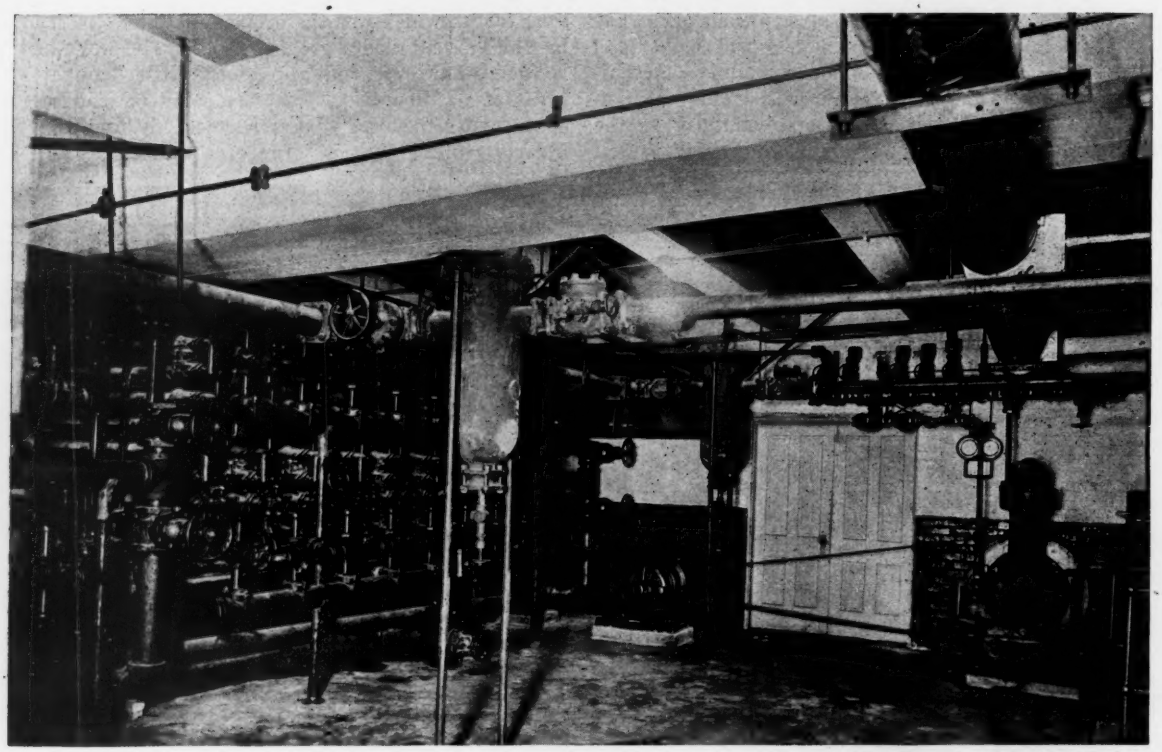


FIG. 3. COUNTER-FLOW DOUBLE-PIPE AMMONIA CONDENSER AND PUMP-OUT COMPRESSOR

Compressor Equipment

Not only is this plant interesting from the standpoint of its location, and we might say, architectural features, but the machinery installed for producing cold is worthy of note. At present only one compressor is in operation, but when completed the plant will have 3 motor-driven York compressors, one of these having a capacity of 100 tons with cylinder dimensions of 15½ by 30 in., and being driven by belt from a 150-hp. G. E. induction motor at 85 r.p.m. The second compressor is

a twin type with cylinders 15½ by 30 in., rated at 200 tons and will be driven by a 300-hp. variable speed motor at a normal speed of 72 r.p.m. The third compressor is also twin type, cylinders 19½ by 34 in., with a rating of 340 tons, and driven by a 500-hp. variable speed motor, normal speed 72 r.p.m. In addition to these a 6-ton machine is provided to pump out compressors, cooling and condenser coils, the piping being so arranged that any coil or section of the piping can be pumped out without affecting the operation of the rest of the plant.

On the compressors, the back pressure carried is 5 to 15 lb., depending upon atmospheric temperature outside, and head pressure is 170 lb.

Condenser

Shipley counter-current, double-pipe flooded condensers are installed, with inside or water pipe 2 in. in diameter, and outside pipe 3 in. At present there are 20 condenser stands, each 8 pipes high and 18 ft. long; to these will be added 20 more stands 12 pipes high and 18 ft. long when all compressor units are installed.

The principle of operation of this condenser is illustrated in the accompanying drawing. An ejector apparatus, X, through which the hot ammonia gas discharges into the condenser, draws in cool liquor from the condenser with the gas from the compressor, thus giving an intimate mixture and condensing most of the gas; the mixture is delivered to the condenser coils, which have little work to perform other than cooling the liquid, as the greater portion of the gas has been condensed due to the ejector action.

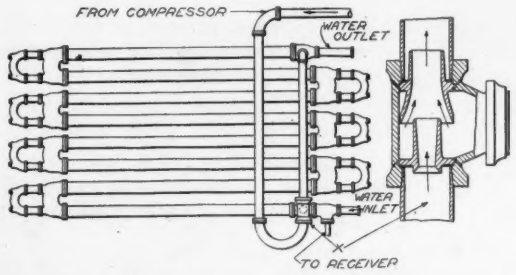


FIG. 4. DIAGRAM OF SHIPLEY FLOODED CONDENSER

At present, cooling water is taken direct from the city mains and runs to the sewer when hot. It is planned, however, to install a 1200-gal. per min. cooling tower, on a corner of the roof not occupied by railway tracks, to cool the condensing water. For circulating the water 2 500-gal. centrifugal pumps will be used.

Cooling Coils

In all sharp freezers, direct expansion coils are used, the temperature maintained in one of these being from —10 to —12 deg. F.; 4 rooms, however, having direct expansion coils are kept at 10 deg. F. In the egg and apple rooms brine coils are installed and the temperature maintained here is 30 deg. F. In all there are 8 compartments, each of which has a capacity of 175 to 200 carloads of produce.

The proportion of space to direct expansion coil surface in the sharp coolers is 6 cu. ft. to 1 sq. ft., in the 10 deg. rooms, 10 to 1; while in the egg and apple rooms it is 15 cu. ft. to 1 sq. ft. of brine coil surface. Direct expansion coils are of 2-in. pipe, the total area being 630,000 sq. ft.; brine coils are of 1½-in. pipe, and the total area is 50,000 sq. ft. Although the compressors are located at about the center of the plant, one 6-in. suction is 650 ft. long, which gives some idea of the size of the plant.

Insulation

Without proper insulation a plant such as here described would be practically impossible, and this detail has been carefully worked out. On the floor, which was originally of cement 6 in. thick, was placed 6 in. of cork board laid in pitch with broken joints; on top of this a 3-in. cement floor was laid to take the wear of truck wheels.

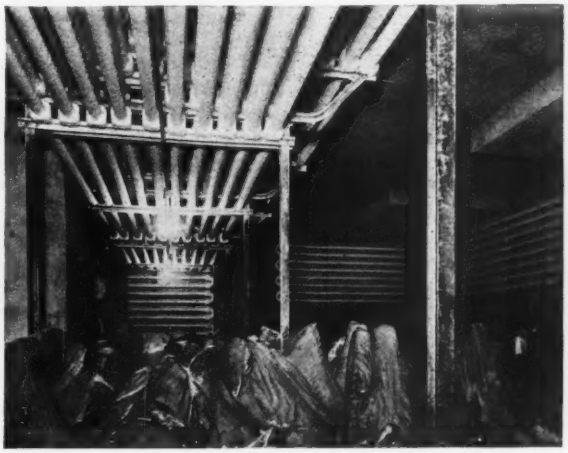


FIG. 5. TYPICAL COLD STORAGE ROOM SHOWING METHOD OF SUPPORTING COOLING COILS

Ceilings were of reinforced concrete, 18 in. thick. These were chipped and washed with acid, then one layer of cork board was put on with cement plaster. The second layer of cork board was put on with cement and wooden skewers, covered with a scratch coat and finish coat of cement. The total thickness of insulating material is 5 in. Outside walls are finished in the same manner as the ceilings.

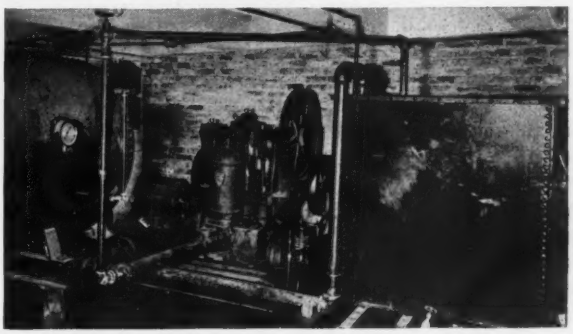


FIG. 6. HYDRAULIC ELEVATOR PUMP AND EXPANSION TANK

All cooling coils are supported from the floor on angle irons, thus doing away with the necessity of breaking the insulation. All cold transmission pipe lines are insulated with 3-in. cork block and are carried overhead to the various parts of the plant.

Returns from the expansion systems pass through accumulators on their way to the compressors, the object of this being to cool the liquor as it passes to the system and trap any flushes of liquor from going to the compressors.

As previously stated, there are 2 hydraulic plunger-type elevators in the plant, each with a capacity of 3 tons. Their purpose is to carry trucks between the grade level of the tracks and the floor of the warehouse. To furnish pressure for the elevators a Goulds triplex pump is provided which is run by a 10-hp. G. E. motor and is capable of delivering 150 g.p.m. against a working head of 135 lb.

Electric Power

Power for operating all machinery is taken from the mains of the Commonwealth Edison Co., at 15,000 v., and transformed to 440 v.; 3-phase current at 60 cycles is used. This plant is particularly well located for using central station current as the principal transmission lines of the company pass but a short distance from the plant, so that an interruption of service would be possible only under very extreme circumstances.

Being a steady load that is thrown off during the peak load period of the central station, which is between 4:30 and 8:30 p. m., during the months of November, December, January and February, an exceptionally low rate for power is obtained.

For carrying produce about the plant, electric storage battery industrial trucks are used, these being charged from a motor-generator set consisting of a 440-v., 3-phase, 60-cycle motor and a 40-v. d.c. generator.

Engineering and erecting work of the plant has been carried on under the direction of Westerlin & Campbell Co., and is being rapidly pushed to completion. As the facilities of the plant make it most desirable to customers, there is a steady demand for more cold storage space, and as fast as the rooms are put into shape they have been filled with produce. As an example of the rapidity of erection, it is stated that from the time foundations were started until one room was cold and ready for use was 23 days.

Investigation of the Pressure Drop in Steam Pipes

By M. Guilleaume*

IT may be considered that the hourly heat loss in any system of steam piping is known to be a constant quantity. According to the contribution of Eberle to the Verein deutscher Ingenieure, this loss, with covered pipes and superheated steam at 626 deg. F. amounts to about 550 B.t.u. per sq. ft. per hour.

The proportion of this constant loss, for which an increased expenditure of fuel is necessary, with regard to the total fuel consumption of a power plant, will be the greater the smaller the volume of steam passing hourly through the pipes. From this it follows that for fuel economy the highest possible steam velocity must be employed. On account of the reciprocatory movement of the steam in the cylinder, considerations of safety for the plant limit the steam velocity to 80 to 100 ft. a second. The absence of the reciprocatory action in a turbine system removes this limit; nevertheless, there are circumstances which make a higher steam velocity undesirable. For instance, a high velocity is accompanied by considerable fall of pressure in the piping; necessitates increased cost for heavier machinery, which would be less efficient; and in addition the outlay for repairs or replacement is increased; any one of which considerations might offset the economy of heat resulting from higher steam velocity. The relation between fuel economy and loss of pressure in the piping must therefore be always kept in mind.

Experience shows, however, that the formulas in use at present for the calculation of the pressure drop in pipes are insufficient: that they constantly prove of little value, and that in actual practice, with high steam velocity, they may lead to serious errors. The following suggestions are offered as the result of tests made at the Berliner Elektrizitats Werke, and also as the result of an exchange of opinion among the members of the Vereinigung der Elektrizitatswerke, with regard to the insufficiency of the formulas at present in use.

Interest of engineers responsible for the heat consumption of a power plant may be increased by the fact that these tests were made by the disconnection of a pipe line which had been installed with special consideration for the pressure drop, in order to bring about a saving of fuel amounting to many thousand marks yearly. The shutting off of this pipe line was made possible by the substitution of parts of the system showing a small resistance for other parts having high resistance. After the disconnection the steam velocity in the remainder of the system rose to nearly double the original. In spite of this the pressure drop was kept within such limits that the full engine supply was not reduced.

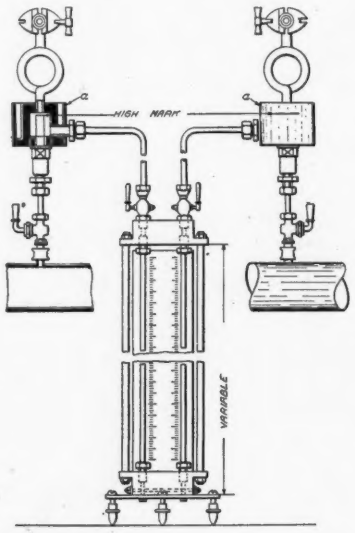


FIG. 1. DIFFERENCE MERCURY MANOMETER

*Chief engineer of the Berliner Elektrizitate Werke, in Feuerungstechnik. Translated and abstracted by J. H. Blakey.

Considering that the testing laboratories of the technical schools can scarcely compete with a properly equipped boiler plant, with its higher steam velocities and larger pipe diameters, in an investigation of this kind, it seems desirable to give the experiments a wider publicity than they would have among the members of the association.

Brief Survey of Formulas Now in Use

Pressure drop of steam, saturated or superheated, moving in pipes, is calculated by means of the following formula:

For smooth pipes, without change of direction, valves, or other obstruction:

$$P_1 - P_2 = 14.22 \left[R \times \frac{d}{0.062} \times \left(\frac{V}{3.28} \right)^2 \times \frac{L}{D} \right] \qquad \text{(Form. 1)}$$

in which P_1 = initial press. lb. per sq. in.
P_2 = final press. lb. per. sq. in.
R = resistance coefficient for pipe.
d = av. density of steam, lb. per sq. ft.
L = length of piping in in.
V = av. steam velocity, ft. per sec.
D = in. dia. piping.

Gutermuth gives for the value of R, 15×10^{-8}, Eberle, 10.5×10^{-8}, Fritsche.

$$\frac{9.4}{10^8 \left(\frac{d}{0.062} \times \frac{V}{3.28} \right)^{0.148} \times \left(\frac{D}{39.37} \right)^{0.269}} \qquad \text{(Form. 2)}$$

For the resistance of a globe valve, Eberle's experiments with 2¾-in. pipe show it to be equal to 55 ft. of pipe of the same diameter.

The above formulas are in common use in Germany, and are employed in all the text books on thermodynamics. Their correctness, however, is only accepted, not proven, and their insufficiency can be shown by examples.

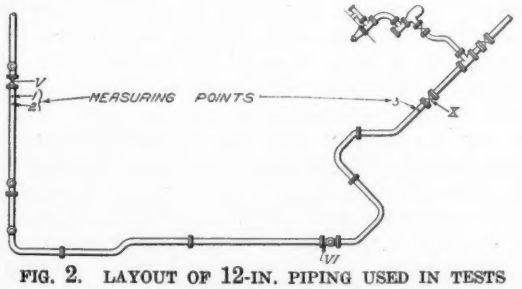


FIG. 2. LAYOUT OF 12-IN. PIPING USED IN TESTS

In a certain pipe line, with a steam velocity of 98 ft. per sec. and density 0.297, the formulas gave a pressure drop of 2.4 lb. per sq. in., whereas a measurement gave an actual drop of 8.3 lb. per sq. in. An increase of the steam velocity to 180 ft. per sec., gave an observed pressure drop of 28.4 lb. per sq. in., while the calculation gave only 7.96 lb. Similar cases are found in daily experience, and all show that with high steam velocities the difference between the calculated and actual pressure drop is so great as to make the formulas worthless. Consequently it was necessary to abandon them entirely and work out new ones.

Measuring Instruments and Method of Test

Measurement of the pressure drop was made in millimeters by means of the mercury column. The instrument employed is shown in Fig. 1. The measuring points are not directly connected with the manometer; condensation receptacles a, a, are placed between steam pipe and instrument. The supporting pipe connecting these receptacles with the main line projects into the vessels to a point indicated on the outside as the "High mark." The vessels are jacketed and cooled with running water, so that the entering steam is condensed. The pipes connecting the vessels with the manometer are therefore filled with water up to the high mark, so that the height of the water column above the mercury can be exactly determined. The surface of the water column in the condensation vessel is, moreover, so much greater than a section of the mercury that small fluctuations of pressure produce only immaterial variations in the height of the column. The effect of errors in reading is the greater the smaller the difference of pressure. The tests were therefore made, as far as possible, with high steam velocities. As the apparatus had to be used occasionally in places where radiation of heat caused a sensible warming of the water and mercury, in such cases allowance was made for this increase of temperature. Readings were made at 2-minute periods in a test lasting at least 20 minutes, under conditions as nearly as possible constant.

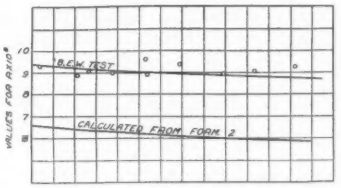


FIG. 3. CURVES SHOWING VALUES OF R FROM FORMULA 2 AND RESULTS OF B. E. W. TESTS

The measuring points could be chosen at any part of the pipe line. With the measurement of the pressure drop in a valve, a drop of from 40 to 50 per cent less was observed when the measuring point was taken withing the flange, on account of the whirling motion of the steam. For this reason the points were chosen about 8 in. beyond the flange, where it was found that constant readings were possible.

The determination of the steam velocity was made as follows: The volume of steam passing over a measured distance and operating one or more turbines, was condensed in a surface condenser, and the condensate carried off into a tested measuring reservoir. The condensate was weighed every 3 or 5 min. The apparatus for measuring the steam consumption of the turbines was sufficient for the measurement of 176,000 lb. of steam an hour. A test was recorded only when at least 4 consecutive measurements showed close correspondence, which, on account of the small fluctuation of steam pressure in the boiler, was easily attained.

Measurement of the turbine condensate showed this to be practically equal to the boiler feed water, so that when a condensate measurement was not possible, the volume of steam was determined by measurement of the feed water. The absolute steam pressure was ascertained by means of a tested gage at the entrance of the measured length of pipe, the prevailing atmospheric pressure at the time being noted. Steam temperature was determined by mercury thermometers at each end

of the measured distance, and these thermometers were compared with a standard after each test. Corrections were made for the projecting portion of the mercury according to the formula

$$k = n\frac{t_1 - t_2}{6300}$$

Steam volumes were taken from the tables of Mollier, corresponding to the various temperature and pressure readings. The tests covered the determination of pressure drop in, 1. Straight pipe; 2. Turns and expansion bends; 3. Globe and gate valves; 4. Spherical T pieces; 5. Frequently occurring pipe combinations, such as connections from boiler to steam headers, or from the entrance of the steam separator to the nozzles in a steam turbine.

TABLE GIVING RESULTS OF THE B. E. W. TESTS ON PRESSURE DROP IN STEAM PIPES

Name of Part	No. of Tests	Steam Vel. ft. sec.	Abs. Pres. lbs. sq. in.	Pres. Drop lbs. sq. in.	R.	R. Average	Remarks
COVERED PIPE							
12 in.	1 to 6	157 156	116 193	1.52 2.53	9.0×10^{-8} 9.3×10^{-8}	9.1×10^{-8}	178 ft. long
12 in.	7 to 11	159 156	87.5 130.5	1.18 1.73	9.3×10^{-8} 9.6×10^{-8}	9.2×10^{-8}	174 ft. long
12 in. Bend	4	105	185	.2		10.3×10^{-8}	
VALVES, GLOBE							
4 in.	4	150	180	4.6		27.2×10^{-8}	Normal Position
8 in.	7	150	170	4.0		31.2×10^{-8}	Normal Position
12 in.	4	140	190	5.7		43.5×10^{-8}	Reversed Flow
12 in.	11	156 159	87 199	2.5 5.3	35.8×10^{-8} 35.7×10^{-8}	35.8×10^{-8}	Normal Position
14 in.	4	100	192			36.3×10^{-8}	Normal Position
VALVES, GATE							
8 in. Ferranti	17	158	140	2.1		18.3×10^{-8}	Superheated Steam
11 in. Ferranti	6	165	142	2.8		22.4×10^{-8}	Superheated Steam
12 in. Ferranti	6	160	170	3.6		25.2×10^{-8}	Superheated Steam
8 in. Hopkinson full passage	13	194 195	146	.14 .29	$.87\times10^{-8}$ 1.66×10^{-8}	1.3×10^{-8}	Superheated Steam
12 in. Hopkinson full passage	8	159 163	162 188	.1 .07	$.79\times10^{-8}$ $.46\times10^{-8}$	$.74\times10^{-8}$	Superheated Steam
8 in. Hopkinson 3/4 passage	10	194 198	182 181	.85 .82	3.65×10^{-8} 3.49×10^{-8}	3.82×10^{-8}	Superheated Steam
12 in. Hopkinson 3/4 passage	4	164 165	161 161	.34 .37	2.4×10^{-8} 2.7×10^{-8}	2.51×10^{-8}	Superheated Steam
8 in. Konig 2 in. hub	11	156 165	150 191	2.75 3.6	22.7×10^{-8} 22.3×10^{-8}	21.92×10^{-8}	Superheated Steam
8 in. Konig 2-5/8 in. hub	6	194 198	99 180	2.3 4.1	17.8×10^{-8} 17.0×10^{-8}	17.37×10^{-8}	Superheated Steam
12 in. Spherical Tee	7	56 87	210 201	.9 2.3	42.7×10^{-8} 37.2×10^{-8}	41.1×10^{-8}	
BOILER TO HEADER							
B. & W. Boiler	1	48.4	203	5.9			
" " "	1	36	153	3.3			
" " "	1	42	178	4.5			
" " "	1	54	229	7.4			
Borsig Boiler	1	71.37	222	6.5			
" "	1	56.8	176	4.1			
" "	1	63	200	5			
" "	1	68.2	215	5.9			
" "	1	74	230	7			
" "	1	79.6	250	8			
TURBINES							
Through Steam Separator & Valve	3	100 to 115	135	7			

Pressure Drop in Steam Pipes

A pipe of 12 in. inside diameter was first tested, 11 tests, each of 1 hr. duration, being made. Figure 2 shows the pipe drawn to scale, all bends being turned into the horizontal plane. For tests 1 to 6, the measured distance extends from measuring points 1 to 3. The density of the steam was varied by means of the throttle valve V. In order to make sure that the action of the valve did not affect the measuring point a second point, nearly 5 ft. distant from the flange was chosen, so that tests 7 to 11, over the distance 2 to 3, could be compared with tests 1 to 6. Point 3 is 8 in. distant from the flange of valve X. The length of pipe from 1 to 3 is 178 ft.; from 2 to 3, 174 ft.

In this measured distance are included 7 cast-steel flanges, with the pipe rolled in; one tee, VI, through which during the test steam flowed without change of direction, and 9 bends of varying radius and length. The absolute pressure at 3 was determined by means of a steam gage, the pressure drop in the measured distance found with the manometer. The average of 2 observations in each test was recorded. Pipes were covered with 2.4 in. of Kieselgur insulation. Average steam temperature was found by taking temperature at the beginning and at the end of the measured distance.

Tests 1 to 6 were made at absolute pressure varying from 116 to 195 lb. per sq. in. at steam velocity of about 157 ft. per sec. Pressure drop varied from 1.52 lb. at 116 to 2.53 lb. at 195 lb. The average value of R, calculated from Fritsche's equation, for the 6 tests was 9.11×10^{-8}. Tests 7 to 10 were made at absolute pressure varying from 87.5 to 130.5 lb. per sq. in., giving pressure drop of 1.18 and 1.73 lb. respectively at these pressures. The average value of R, calculated as before, was 9.19×10^{-8}.

The value of R reckoned from Formula 2 gives the lower curve in Fig. 3, while the upper curve shows the results given by the tests. For a determined diameter of pipe, R may therefore be considered as nearly constant. The tests gave, for a 12-in. pipe, an average value of R, 9.15×10^{-8}, which is about 50 per cent higher than that given by Fritsche's formula. The difference is to be accounted for by the fact that Fritsche's experiments were with a straight, smooth laboratory pipe, whereas the pipe used in the B.E.W. tests was the ordinary pipe used in power plants, with flanges, bends, and spherical tee. The corrected formula will therefore read

$$R = \frac{1.5 \times 9.4}{10^8 \left(\frac{d}{0.062} \times \frac{V}{3.28}\right)^{0.148} \times \left(\frac{D}{39.37}\right)^{0.269}} \qquad \text{(Form. 3)}$$

In a 328-ft. length of 12-in. pipe, having bends and spherical tees similar to Fig. 2, with a steam velocity of 262 ft. a sec. and density of 0.297, Form. 3 gives a pressure drop of 11.8 lb. per sq. in. Substituting Eberle's value of R, 10.5×10^{-8}, which serves for all pipe diameters, we have 15.2 lb. per sq. in. As the difference between these 2 results is so small (about 1 lb. per sq. in. per 100 ft. of pipe), the simpler formula of Eberle may be taken as giving results close enough for practical purposes.

Pressure Drop in Bends

The expansion bend tested was of 12-in. pipe, as shown in Fig. 4; 4 tests being made. The average value of R was found to be 11.33×10^{-8}, with average steam velocity 105.6 ft. per sec. and density 0.282. For these

conditions the value of R for straight piping according to Fritsche's formula is 6.81×10^{-8}. For a bend of the given radius of 12-in. pipe, the value of R is thus about 66 per cent higher than for straight pipe of like diameter, as given by the formula. The investigations of Bach & Stuckle in 1913 gave for a bend of 2¼-in. pipe, a value of $R = 16.35 \times 10^{-8}$, whereas for a straight pipe of this diameter Form. 2 gives $R = 9.13 \times 10$; therefore for a bend, the value of R is here 79 per cent greater than for straight pipe of the same diameter. Therefore, in reckoning pressure drops in bends, the value of R as found by Form. 2 must be multiplied by 1.7. The effect of the radius of the bend was not tested. The pipe was covered with 2½ in. of Kieselgur insulation.

Test of a corrugated pipe bend, 12 in. diameter, gave an average $R = 113 \times 10^{-8}$, which is 10 times that of Fig. 4. The greater resistance is here due partly to the corrugations and partly to the increased curvature of the bend, which had one radius of 18 in. and 2 of 15 in. In the investigation of Bach & Stuckle, bends of the same radius in smooth and corrugated pipe were tested; the value of R was in this case about double for the corrugated pipe.

Pressure Drop in Globe and Gate Valves

Globe valves of 14, 12, 8 and 4 in. diameter were tested, the valves so placed that the steam direction was from below the seat. In the case of the 12-in. valve, tests were also made with steam flowing in the opposite

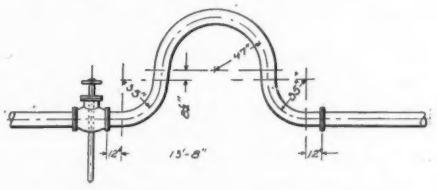


FIG. 4. REVERSE BEND OF 12-IN. PIPE

direction. The steam passing through the valve was measured as turbine condensate, as before, and the measuring points were 8 in. on each side of the flange. To diminish the effect of unavoidable errors in measurement, and of small fluctuations of pressure, a high steam velocity was used, the arrangement of piping, turbines and measuring tank being shown in Fig. 5.

Eleven tests were made with the 12-in. globe valve in the normal position in the piping, that is, with steam flowing from below the valve seat. Pressures varied from 87 lb. and steam velocity 159 ft. a sec. to 199 lb. and velocity 156 ft.; for the first, pressure drop was 2.55 lb. and $R = 35.85 \times 10^{-6}$; for the second, pressure drop was 5.4 lb. and $R = 35.75 \times 10^{-6}$. The average value of R, calculated as before, for the 11 tests was 35.85×10^{-6}.

Four tests were made with valve in the reverse position, that is with steam flowing from above to below the seat. In these tests, with average absolute pressure of 190 lb. and average steam velocity 140 ft. a sec., the average pressure drop was 5.7 lb. and average value of $R = 43.5 \times 10^{-6}$. It will be observed that with the steam flowing from above the valve seat, the average value of R is about 20 per cent greater than with valve in normal position. That the pressure drop in a valve increases approximately as the square of the steam velocity is shown by Fig. 6, which indicates in graph form the resistance of the valve to steam flowing in different directions. The curves approach a parabola, as is to be expected from the equation Form. 1.

In the tables given by the author the value of R for the several tests is calculated. The different values agree well with the changing values of d, thus proving the correctness of Form. 1. To what extent the change in the value of R is dependent upon the construction and diameter of valves, is shown by the tests which follow.

Four tests of a 14-in. globe valve in normal position, with average steam velocity 100 ft. a sec., average pressure 192 lb. abs., gave an average pressure drop of 2.5 lb. per sq. in. and average value $R = 36.3 \times 10^{-6}$.

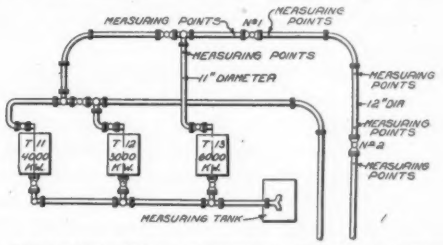


FIG. 5. ARRANGEMENT OF TURBINES AND PIPE USED IN TESTS

Eberle tested a 2¾-in. diameter valve, and found a value of R, 25.56×10^{-6}. Consequently we have the following:

VALUES OF R FOR GLOBE VALVES OF DIFFERENT SIZES

Diam., In.	Tested by	Value of R
2.75	Eberle	25.56×10^{-6}
4	B. E. W.	27.25×10^{-6}
8	"	31.22×10^{-6}
12	"	35.85×10^{-6}
14	"	36.30×10^{-6}

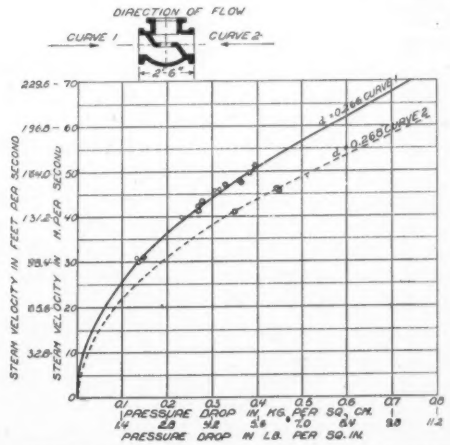

DIRECTION OF FLOW
CURVE 1
CURVE 2
2'-6"
STEAM VELOCITY IN FEET PER SECOND
PRESSURE DROP IN KG. PER SQ. CM.
PRESSURE DROP IN LB. PER SQ. IN.

FIG. 6. CURVES OF PRESSURE DROP IN GLOBE VALVES AT VARYING STEAM VELOCITIES

While with smooth piping the value of R decreases with increasing diameter, with the tested globe valves it increases with increasing diameter. It seems probable, therefore, that with increasing valve diameter the placing of the valve in a limited length of piping produces an increasing diminution of the free steam passage, and thereby causes a whirling and friction which increases resistance.

The pressure drop in a valve is given by the equation

$$P_1 - P_2 = 14.22 \left[R_V \times \frac{d}{0.062} \times \left(\frac{V}{3.28} \right)^2 \right] \qquad \text{(Form. 4)}$$

and that in smooth piping by the equation

$$P_1 - P_2 = 14.22 \left[R_P \times \frac{d}{0.062} \times \left(\frac{V}{3.28} \right)^2 \times \frac{L}{D} \right]$$

Therefore, to find a length of pipe causing pressure drop equal to that of the valve, we have, with the same diameters, and d and V the same,

$$L = D \times \frac{R_V}{R_P}$$

For valves of the investigated diameters, the pipe lengths having equal resistance are found to be as follows, using the value of R found for each valve diameter and for simplicity the constant 10.5×10^{-8} for pipe resistance:

For 2.75-in. valve, the equivalent pipe length is 55 ft.
4 -in. valve, the equivalent pipe length is 85 ft.
8 -in. valve, the equivalent pipe length is 195 ft.
12 -in. valve, the equivalent pipe length is 334 ft.
14 -in. valve, the equivalent pipe length is 396 ft.

From this it will be seen that the generalization of Eberle, arrived at as the result of a test of one valve, that its resistance equals that of about 55 ft. of pipe of the same dia., is correct in only one case, and that its general use leads to greater errors the larger the diameter under consideration.

In piping on which the tests were made (12-in.), were 2 14-in. and one 12-in. valve, the pressure drop for each of which had been considered as equal to 52 ft. of pipe. Therefore, in accordance with results arrived at, it was necessary to add 278 — (330 — 52) ft. for the 12-in. valve; and 688 — 2(396 — 52) ft. for the 14-in. valves. With a steam velocity 98 ft. a sec., and density 0.29, we have by Form. 4, for the 12-in. valve, 1.85 lb. per sq. in., and for the 14-in. valves, 3.75 lb. per sq. in., together 5.6 lb. per sq. in. Pressure drop for the whole pipe would then be 2.4 + 5.6 = 8 lb. per sq. in., whereas measurement gave 8.3 lb.

The frequently observed fact that piping of large diameter always gives by measurement a higher pressure drop than is to be expected from the calculations, is in most cases no doubt due to allowing too small values for valve resistance.

The above mentioned fact that the resistance of a globe valve increases approximately as the square of the steam velocity leads to the conclusion that for high velocities some other form of valve offering smaller resistance should be used. (To be continued.)

Efficient Operation of Boiler Rooms

CENTRAL STATION PLANT HAS EXCELLENT COAL HANDLING SYSTEM; IMPROVEMENTS MADE IN STOKERS, DRAFT CONTROL SYSTEM AND FEED WATER REGULATOR; COMBUSTION INDICATOR DEVISED

IN connection with a number of others, the plant we offer for consideration in this article furnishes power for street and elevated railways, also for commercial purposes in one of our coast cities. It is located on a harbor and all coal comes to the plant in barges.

The steam generating equipment consists of 20 B. & W. boilers, arranged in 2 rows facing each other with 2 boilers to a setting; 4 boilers make up a group which has one lead to the steam main. They are rated at 600 hp. capacity each, served by 7-retort Taylor stokers and equipped with B. & W. superheaters.

The boiler tubes are 4 in. in diameter by 18 ft. long, arranged 14 tubes high and 21 wide, and are connected through headers to 3 42-in. drums. The superheater is located in the first pass, and the distance between the grate and the first tubes of the boiler is 8 ft.

These boilers are served by 2 stacks 13 ft. in diameter by 215 ft. high, supported on steel work and placed directly over the boilers, the gases passing around the steam drums near the rear end and it is reported that considerable saving in heat is thus effected.

All stokers were built with a guarantee that they will operate the boilers continuously at 240 per cent of their rating, and at 150 per cent of their rating the boiler efficiency guarantee is 75 per cent.

On each boiler are 3 4-in. saturated steam safety valves and 1 3½-in. safety valve on the superheater; 200 lb. steam pressure is carried on the boilers with the saturated steam safety valve set at 205 lb. and the superheated steam safety valve at 203 lb. To reduce the noise in the plant when a safety valve blows, each valve discharges into a muffler.

In each drum is a perforated dry pipe which leads to the boiler steam outlet. This is of galvanized iron with the holes on the upper side of the pipe. One hundred and twenty-five degrees superheat is given to the steam in passing through the superheater. On the leads to the header are placed automatic nonreturn Schutte & Koerting stop valves.

The water level in the boilers is maintained by means of a Copes feed water regulator of an old type, but did not give the best service, so it was turned over and put on a level with the feed water in the boiler, converting it into what is termed the submerged type; the water is now fed constantly and the level does not vary appreciably throughout the operation in the boiler.

The water columns were furnished with the boilers and are provided with high and low water alarm. A specially constructed float, however, to withstand the high pressure to which the boiler is subjected is employed, and the leverage on the alarm, which was single, has been changed to double, making the alarm more sensitive than it was.

From the bottom of each mud drum are 3 blowoff connections, in each of which is placed an Everlasting blowoff valve; all 3 connections join, and the pipe leading from the boiler is provided with a heavy angle valve.

COAL HANDLING SYSTEM

AT PRESENT, New River coal is used, but sometimes deliveries of Pocahontas are received. The coal is loaded into industrial cars from the barges by means of clam shell buckets and coal towers and hauled by cable to the coal field or dumped upon a belt conveyor

which delivers it to the bunkers in the boiler room. The coal field has a capacity of 70,000 tons at present, which will be increased to 100,000 tons when completely filled in. This field is accessible by a 300-ft. traveling transfer bridge which gathers the coal from the field and dumps it into the industrial cars by means of a grab bucket. A coal crusher is provided through which the run-of-mine is passed before it is delivered to the belt conveyor. All the coal is bought from the mines and every vessel is tested, a sample being taken from the top, middle and the bottom. The average heat value is 14,700 B.t.u. per pound and the percentage of volatile matter is 18.8.

Over the aisle between the boilers are the coal bunkers which have a capacity of 1315 tons and are made of reinforced concrete. From these bunkers the coal is discharged into the hopper of scales which are mounted upon a traveling crane and automatically stamp the

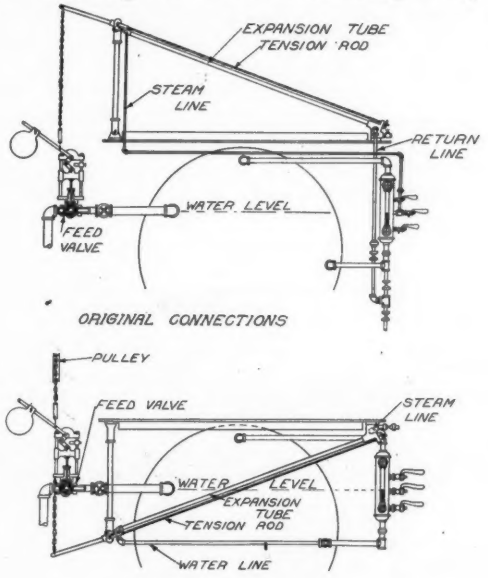


FIG. 1. ORIGINAL AND REVISED FEED WATER REGULATOR CONNECTIONS

weight of the coal in the hopper. This crane travels from one end of the plant to the other and thus can deliver coal from any part of the bunker to any stoker.

It was stated that at times spontaneous combustion has been noted in the coal field and that red hot coals have been taken from the field, mixed with cold coal, conveyed to the bunkers and fed to the hoppers of the stokers without injury to any of the conveying machinery. While this practice is, of course, not common nor desired, it shows what can be done in an emergency and the rapidity with which the coal may be used to prevent a serious fire in the coal field.

Operating Features

Labor of the firemen in this plant has been cut to a minimum largely because of the system of forced draft control and automatic regulation of the speed of the stoker engine. The original arrangement was to control the stoker engine speed by hand regulation, the pressure in the wind box being regulated automatically inversely as the steam pressure in the boilers, i.e., when steam pressure goes up, the forced draft pressure goes down, due to the action of the regulator on the fan engine. As might be expected, this arrangement demanded continual change of the stoker engine speed to meet the load conditions. The only means for telling the condition of the fire at that time was through observation holes and such constant observation was necessary that combustion conditions were not as good as was considered possible.

To overcome this inconvenience of hand regulation, the engineer in charge devised a scheme by which the stoker engine speed is regulated in proportion to the air pressure in the wind box. The arrangement is shown in diagram Fig. 2. A box similar to a bellows

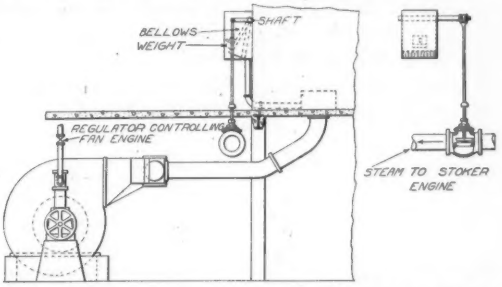


FIG. 2. DIAGRAM OF FORCED DRAFT CONTROL SYSTEM AND METHOD OF REGULATING STOKER SPEED

is connected to the wind box. The movable side is fastened to a shaft at the upper end and is weighted according to the load desired on that boiler. The position of this movable side of the bellows is determined by the air pressure in the wind box and the weights placed upon it. In order to drive the stokers at the proper speed, therefore, it is only necessary to connect the shaft operated by the bellows through a system of cranks and rods to the governor valve on the engine, the governor weights having been removed. This was done as indicated in the diagram.

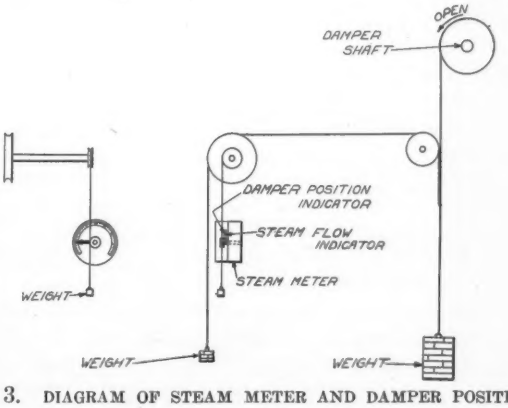


FIG. 3. DIAGRAM OF STEAM METER AND DAMPER POSITION INDICATOR WHICH SHOWS WHEN FURNACE CONDITIONS ARE CORRECT

When in operation a slight decrease in steam pressure causes the fan to increase its speed, which in turn raises the pressure in the wind box. This acts on the bellows which admits more steam to the stoker engine, increasing its speed and forcing more coal into the furnace to give the necessary increase in combustion to raise

the steam pressure back to normal. So accurately does this system work that one fireman is able to tend the fires of the entire 20 boilers and maintain proper load relations among the boilers.

The Blaisdell-Canady system of balanced draft control, supplemented by an auxiliary hand damper in the breeching of each boiler, is employed on each boiler and is set to maintain a draft of 0.03 in. over the fire. The air pressure maintained under the furnaces varies from 1 to 4½ in. of water, according to the load which is being carried by the boiler. The average thickness of the fire carried on the stokers is 18 in.

On each boiler is placed a combustion indicator, devised by those in charge, which is essentially a steam flow meter of the indicating type and a damper position indicator with both hands on the same dial, the damper being under the control of the balanced draft system. With proper combustion, and drop in draft through the setting, adjustment of the damper position indicator is

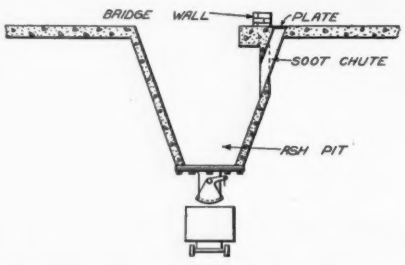


FIG. 4. CROSS-SECTION OF ASHPIT WITH CHUTE TO REMOVE SOOT FROM BEHIND BRIDGE WALL

such that the hands of the instrument will coincide in position throughout the range of load on the boiler. Any holes in the fire, fallen baffle or accumulation of soot on the boiler tubes will be noted by a change in the damper position which is plainly indicated by the meter and attention is immediately called to the condition.

Difficulty was had in the operation of the stoker due to the piling up of the coal on the dump plate and to overcome this the stroke of the lower plungers was shortened from 1⅞ in. to ⅞ in. Also the dump plates have been changed to special casting which can easily be renewed and the extension grates are now made up of special bars inclined toward the ash dump and placed edgewise instead of the flat type extending across the furnace ordinarily employed in the construction of this type of stoker. The dump plates are operated every 2 to 3 hr., according to the load carried.

Wet coal is sometimes used, which presented difficulty in feeding from the stoker hoppers, and to overcome this, agitators operated by endless chain from the crankshaft have been placed in the hoppers of all stokers.

The average coal consumption runs from 1.7 to 1.8 lb. per kw.-hr. and the daily average has run as low as 1.68 lb.

As an aid to the firemen, a load board is located in the boiler room which shows in thousands of kilowatts the load being carried by the station. This gives the operators an opportunity to know about how many boilers to keep in operation, and whenever a change is to be made in the number of turbines being operated, the fireman is notified by a telephone message from the switchboard attendant.

It is customary to carry the boilers, which are necessary during the peak period, in operation throughout the entire 24 hr. This gives an average of about 1250 hp. per boiler during the non-peak load. During the cleaning period of the day, however, the load on the boiler being cleaned is run down to about 800 or 1000 hp. in order that the work may be done quickly and with the least amount of waste.

An automatic non-return stop valve in the steam lead from the boiler cuts the boiler in or out of the line as the intensity of the fire is raised or lowered.

A record of the amount of the coal which is used in the plant is kept by means of scales which record the weight as the coal is delivered to the boiler.

There is no means for measuring the water as it is fed to the boiler, but an indicating flow meter shows the rate of steaming and is an aid to the fireman in showing the load on his boilers.

Feed water temperature is shown by a recording thermometer and varies from 190 to 210 deg., as the water enters the boiler. Flue gas temperatures are taken during tests which are run occasionally, and these vary from 500 to 600 deg.

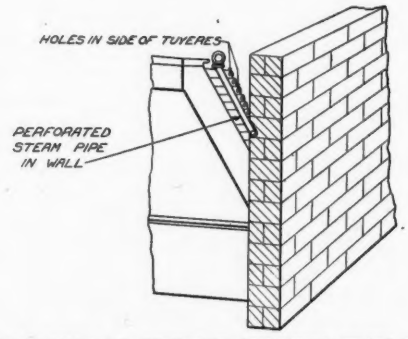


FIG. 5. PROVISION TO PREVENT CLINKERS FROM FORMING OVER SIDE OF STOKER

The percentage of CO_2 in the gases is also taken only during tests, and at such times has been found to be from 13 to 15 per cent, an Orsat instrument being used for this purpose.

Ashes and soot are removed by means of industrial cars which run beneath the boilers in the basement, the ashpit being in the form of a hopper which is provided with a gate used in discharging the ashes into the car and the soot is emptied by pushing it through a chute leading from behind the bridge wall to the ashpit.

Considerable difficulty was encountered with clinkers attaching themselves to the side of the furnace above the stoker tuyeres and has been considerably overcome by drilling holes in the side of the tuyeres which discharges the air against the side of the furnaces. In addition to this a perforated steam pipe is placed between the side of the stoker and the furnace wall. From this pipe steam is allowed to discharge slowly, and this in connection with the air from the tuyere lowers the temperature of the clinker on the side of the furnace below the fusing point, thus making it comparatively easy to remove while the boiler is in operation.

Feed Water

Feed water to the boilers is principally the returns from the condensers, the hot well water going to the heater, the water level of which is maintained by means of an automatic float valve on the city water supply pipe. Circulating water which is used for cooling the compensators in the generating room is also fed to feed water heaters and used to feed the boilers. There are 2 Cochrane open feed water heaters in the plant which take exhaust from all auxiliaries at a back pressure of 1 lb. All steam piping is drained by means of a Holly return system which delivers the condensate to the hot well. The boilers are fed by means of multi-stage centrifugal feed pumps driven by Terry steam turbines. Two of these pumps have a capacity of 1000 gal., one 500 gal., and the fourth 1200 gal. per min.; the latter being a 3-stage, while the others are 4-stage pumps. To the boilers are 2 feed lines, one running over the top. the other in the basement under the boilers; the latter being that commonly used since the former was put in as an emergency and not insulated.

The feed line discharge is through the front head of each boiler drum, the pipe entering below water level and ending about a foot beyond the steam baffle.

Feed water being largely the returns from the condensers and the makeup water containing so little scale-forming impurities, no treatment whatever is given the water.

Routine of Operation

The safety valves are tested every morning and the blowoff valves are opened once a day. Water columns are blown down once each watch, which means a frequency of 3 times a day.

Water in the boiler is changed once every 2 weeks. To do this, the fire is allowed to burn down, and the steam pressure lowered to about 10 lb., then the blowoff valves are opened, allowing the water to run to the sewer; fresh water is then pumped into the boiler.

It is the practice in this plant to take a boiler out for cleaning every 6 weeks, at which time the 3 lower rows of tubes and 2 extra rows are bored out with a turbine cleaner. For instance, the first time the boiler is down, the lower 5 rows are turbined; the next time the 3 lower rows and the sixth and seventh rows from the bottom; the third time, the first 3 rows and the eighth and ninth. Thus, the tubes are all turbined once in about 9 months. After the boiler has been cleaned and thoroughly inspected, it is tested before being put back into service.

When starting up, the superheaters are flooded with water until the steam pressure rises to 25 or 50 lb., then they are blown down, and by means of the automatic stop valve, the boiler is put into service when its pressure reaches that of the header.

To determine the condition of baffles, the gas pressure, in the various parts of the setting is taken occasionally and compared with readings which were taken when the baffles were known to be in perfect condition.

To repair cracks in the boiler setting, cement is used and for the baffles around the furnace a high temperature cement is being experimented with. No great care is taken to hunt for cracks in the settings, as with the balanced draft system there is but little difference in pressure between the inside and outside of the setting and inleakage is slight.

The boiler room force during each shift, of which there are 3 in 24 hr., consists of a foreman, one fireman and 2 coal passers. This, of course, does not include the men who handle the ashes or do the repair and cleaning work of the boiler plant.

Boiler Feed Water---VIII

Proper Chemical Treatment of Water. By F. F. Vater

I GAVE as a cure for suspended matter, sedimentation, filtration or both, but called your attention to the fact that the cure was named for suspended matter alone, and without considering the nonincrusting and incrusting solids. Where a water, as is almost invariably the case, contains both suspended matter and incrusting solids, the water softener is the perfect cure in that it provides the filter not only for the suspended matter originally in the raw water, but for the incrusting solids as well which become suspended matter after the chemical reactions have taken place.

A device for removing incrusting matter should not be called a purifier. To purify is to remove. In softening water you only partially remove; you just change the impurity from a soluble to an insoluble form, so that it precipitates out of solution.

In a water softener using lime and soda ash, the reactions are as follows: For each grain of sulphate of lime or magnesia, you feed one grain of soda ash or sodium carbonate, which is a combination of soda and carbonic acid. Your lime and magnesia are combined with sulphuric acid as the sulphates. The sulphuric acid goes to the soda, for which it has a greater affinity than for the lime and magnesia, forming, therefore, sulphate of soda. The sulphuric acid, being stronger than carbonic acid, drives it out of the soda. The carbonic acid goes to the lime and magnesia, changing them from the sulphates, which are soluble, to the simple carbonates, which are insoluble.

You have not purified the water for the reason that while you have taken out lime and magnesia, you have created sodium sulphate, which is highly soluble and remains in the water inert, as far as scale formation is concerned, but no less dense.

This is also true with any chlorides of lime or magnesia. The chlorine goes to the soda because of its greater affinity, forming sodium chloride; highly soluble it remains in the water. The carbonic acid contained in your reagent being driven out by the chlorine, which is stronger than the carbonic acid, combines with the lime and magnesia, rendering them the insoluble simple carbonates.

The same reaction and the same result occur with the nitrates of lime and magnesia. In this method, you feed lime for the bicarbonates of lime and magnesia. The excess of carbonic acid goes to the lime oxide fed, form-

ing simple carbonate and changing the bicarbonate into simple carbonate, both precipitating. In this case, you have really purified because you have actually removed an impurity without leaving anything in its place. If the cost of barium hydrate was sufficiently low to permit of its general use, you would really purify a water having both sulphate and carbonate in it, because both the sulphate and carbonate of barium are practically insoluble, so that they would precipitate with the carbonate and sulphate of lime and magnesia, which the reaction or inter-change renders insoluble.

Unfortunately, the cost of barium hydrate is so great, it can be used only in exceptional cases when the savings made justify its cost.

To make this clearer, we will take a concrete example. I gave previously an analysis of a bad water which carried incrusting matter, 34.490 grains per gallon, and non-incrusting matter, 16.878 grains; total solids, 51,368 grains. With a lime and soda ash treatment, there would remain in the water the following named solids:

Substance	Grains per gallon.
Silica	.02
Iron oxide and alumina	.232
Lime carbonate	1.000
Lime sulphate	.000
Magnesium carbonate	1.000
Magnesium sulphate	.000
Incrusting solids	2.252
Sodium chloride	3.828
Sodium sulphate	29.870
Total solids	35.950

This has reduced the density due to the removal of lime and magnesium carbonate, but the sulphate remains as the sulphate of soda. The reduction in density then is from 1.000,88 to 1.000,6.

Had barium hydrate been used as a reagent in treating this water, it would contain, after treatment, the following named solids:

Substance	Grains per gallon
Silica	.02
Iron oxide and alumina	.232
Lime carbonate	1.000
Magnesium carbonate	1.
Incrusting solids	2.252
Sodium chloride	3.828
Sodium sulphate	13.050
Total solids	19.130

with a consequent density of 1.000,3 plus, which is materially better.

A water softener is not, therefore, a cure all, but like any device, should be installed intelligently and under such conditions as make possible its success and hence a dividend payer. It is absolutely a cure for incrusting and suspended matter, but cannot take care of the non-incrusting solids.

There are other ways in which your scale accumulation can to some extent be controlled. They are partial cures only, as I will try to show.

The use of soda ash or caustic soda will help controlling scale troubles if used intelligently. They are the base or active reagent in practically all boiler compounds and cost less money.

I would not recommend the use of lime, unless you spend enough money to equip your plant to handle it properly, and this expense will so nearly approximate the cost of a complete softener that it would pay you to put in a little more money and get the full benefit.

As I have shown where lime is used, you have a double precipitate, viz., the lime and magnesia already in the water and the lime you feed. Unless, therefore, you have a softener, you are increasing the sludge in your boiler by the amount you feed. Again, unless lime is fed with extreme accuracy and you are equipped with the necessary chemical apparatus to know just what you are doing, you will make trouble instead of getting away from it.

Were it possible to use lime as you can use soda ash or caustic soda, it would become a part of every boiler compound, as it is the cheapest reagent known. It cannot be so used, because it is not soluble in water, but is used in a mechanical mixture and therefore must be constantly stirred to keep it mixed. Used in a dry compound, it would deteriorate by absorbing carbonic acid from the air, so that it would become useless. Used in excess, it will form a harder scale than will the carbonate you are trying to remove.

Don't fool with lime unless you have the softener and are equipped to *know* what you are doing.

By using soda ash as a compound, you can change the sulphate of lime and magnesia to the simple carbonate resulting in the scale being soft, more readily removed and less dangerous. It goes into your boiler, however, while the softener removes it from the water before it enters the boiler, which is the only correct way.

In the plant where the savings to be obtained will not justify the installation of a water softener, you can cut out some of your operating cost by using a boiler compound, if you do not want the bother of using caustic soda or soda ash.

Again, there are many small plants with small boiler capacity where the initial investment in a water softener would scare the owner out of 10 yr. growth, where compounds will always be used and their intelligent use is justified.

A compound should be fed regularly every minute the boiler is evaporating water. It will be worth your while to feed it proportional to the water you evaporate. It should be fed into the cold water so that as much precipitate as possible will stop in your feed water heater instead of going into the boiler.

Personally, I would not feed any compound made by anybody unless the manufacturer furnished me with a chemical analysis of his compound. Feeding a compound, resulting in all chemical reactions taking place in the boiler, cannot under any conditions reduce the density of the water and hence cannot better the conditions density causes. At best, it is a makeshift and only allowable under a condition where the cost of operating a softener is not justified by the savings obtained.

In using soda ash, caustic soda or compounds, it will pay you to equip yourself to know what you are doing. For a nominal expenditure, you can purchase a small

chemical set, the use of which shows you by a color change when you have fed enough chemical to bring about the desired reaction. Phenol can be used in connection with a dilute sulphuric acid solution with the necessary burrette, measuring flask, stirring rod and reagents. Titrating the color given to the water by adding phenol with sulphuric acid solution is very accurate, requires little time and gives you absolute control of the situation. Where such substances are used, they should first be fed drop by drop regularly, and should never be fed in excess. Their use should be supplemented by the blowing down and the use of a titrating or chemical set just referred to, will enable you to determine how often you should blow down. The action of caustic soda is slightly different from that of soda ash, for the following reasons:

Soda ash affects the sulphates, chlorides or nitrates of lime and magnesia, but has no effect on the carbonates.

Caustic soda (sodium hydrate) first absorbs the excess carbonic, and in the lime and magnesia changing its own form to soda ash or sodium carbonate, in which form it attacks the sulphates so that you get a double effect.

To the extent that a water is evenly balanced or in other words carries approximately equal quantities of both carbonate and sulphate, it is ideal. Where, however, the carbonates are in excess you can only properly use enough to form sufficient soda ash to bring down the sulphate. If it is fed beyond this your water will be so strongly alkali that foaming will be sure to follow.

To illustrate this further, we will take an example. Say the sulphates of lime and magnesia in a water aggregate 4½ grains per gallon and the carbonates of these substances aggregate 6 grains per gallon. The use of caustic soda would change the bicarbonates to the simple carbonates, forming by the interchange 6 grains of soda ash, which would react on the sulphates, precipitating them and leaving an excess of soda ash of 1½ grains per gallon, which is the maximum amount permissible.

Should the water contain 4½ grains of sulphate and 12 grains of carbonates in the aggregate, and you fed enough caustic soda to precipitate all the carbonate, there would be 7½ grains excess of soda ash in the water, which is too much and would cause you trouble.

I see some of you shake your heads and say, "I would not use caustic soda in a boiler I was operating under any circumstances. I have had trouble before."

Now, if you are going to benefit by what I tell you, you will have to read with open minds and let prejudice slide. I say to you that if you had trouble with the use of caustic soda, the trouble was with the way you used it, and not due to any characteristic of the reagent itself. For instance, if you had the water just cited containing 4½ grains of sulphate and 12 grains of carbonate, and precipitated all the carbonate, you sure would have trouble.

I have heard it said that caustic soda makes boilers leak, but this is all rot. If a boiler is badly scaled to the extent that the tube ends are burned and seams started, and you feed caustic soda until the scale is removed, your boiler will leak; but it is not the fault of the caustic soda, but of the abuse of the boiler in not using caustic soda sooner and preventing the damage the scale did. If you are using a boiler compound on a water of such a nature the chances are eight to one that caustic soda is the base of your compound, even though you bought it for a strictly vegetable compound.

There is no legitimate criticism of caustic soda for remedying scale troubles, and it is like anything else. it will do the work if it is used intelligently.

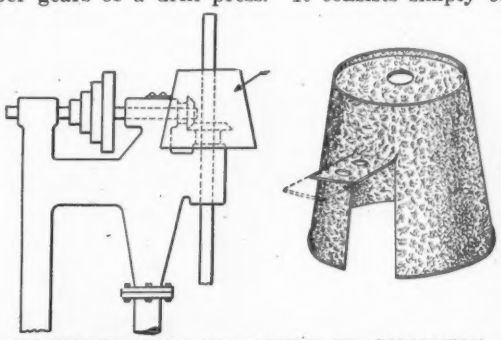
Here is where the beauty of the chemical set comes in. You can use caustic soda, or soda ash, or barium hydrate, and get the finest kind of results if you check what you are doing by titrating to a definite result.

(To be continued.)

A Homemade Guard

IT is not always necessary to expend considerable amounts of time and money in order to provide effective guards and safety devices for dangerous machines. An ingenious person can often make use of homely materials that are near at hand, and fashion them into satisfactory safeguards, at least for temporary use. The result may not be esthetically perfect in every case, but the more important considerations of safety and efficiency may nevertheless be well served.

The accompanying sketch shows a guard that was devised and installed by an employe in a garage, for the upper gears of a drill press. It consists simply of an



HOMEMADE GUARD AND METHOD OF APPLICATION

inverted galvanized-iron pail or bucket, in the bottom of which a circular hole was cut, so that it might be slipped over the projecting end of the shaft. Two cuts were also made with a hack-saw on one side of the pail, as shown, and the strip or tongue of metal thus freed was bent outwardly and attached to the frame of the drill press by 2 capscrews, to hold the pail in position. Although the device is crude, it guards the gears effectively.—The Travelers Standard.

REFRIGERATING PLANTS in South America are largely for the meat packing industry, breweries and ice plants. Of packing plants, 9 are in active operation in Argentina with 4 more projected; for ice making, 13 plants are located near Buenos Aires and 6 breweries are in and near the same city. Anhydrous ammonia for these plants has come largely from the United States, the price being $0.35 a pound in drums of 150 lb. capacity, the container being charged at $17.37 to the consignee with privilege of return and refund.

In Chile, breweries and refrigerating plants use drums of the same capacity, the price for anhydrous being 26½ cents a pound. Brazil pays about 50 cents a pound, but its consumption is small.

Electrical Machinery and Appliances

For Generating, Transmitting and Using Current

Electric Operation and Automatic Electric Control for Machine Tools*

ADVANTAGES OF AUTOMATIC STARTERS; TYPES AND THEIR CONSTRUCTION; PROTECTIVE FEATURES. BY L. C. BROOKS

SIX years ago it was pointed out that for work requiring adjustable speed motors, the direct-current motor alone was applicable. The same is true still, if the desired speed increments are small. Satisfactory results are, however, being obtained with alternating-current in large installations in steel mill and other heavy duty work of large capacity.

CONTROL APPARATUS

CONTROL is the essence of machine-tool operation. It plays the largest part in production work.

While there are a number of instances and special locations where dial or drum type hand starters are more applicable, we have reached the time when automatic starters, remote controlled (with the possible occasional exceptions of the reversing switch) are the most suitable.

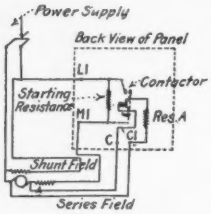


FIG. 1

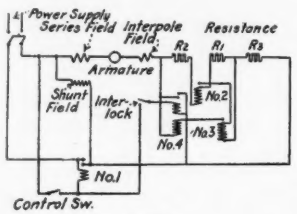


FIG. 2

FIG. 1. CONNECTIONS OF COUNTER ELECTROMOTIVE FORCE AUTOMATIC STARTER; LINE SWITCH IN MOTOR CIRCUIT
FIG. 2. CONNECTIONS OF SERIES TYPE STARTER

The principal advantages of automatic control are: (*a*) Will not cause undue stresses on the motor, especially on rapid reversing equipments. (*b*) The operating switch, or push button, is easily attached to the machine and the main panel may be located at a distant point, out of the way. (*c*) The manufacture of automatic appliances is now a well founded art and is no longer an experiment. (*d*) A considerable increase in the capacity of the machines is obtained. (*e*) The starting time is automatically regulated to suit the load conditions on the motor. (*f*) Accurate stopping points are obtained by the application of dynamic braking, which consists in connecting a resistance across the armature circuit in the *off* position of the starter, the stored energy of the armature being dissipated as heat in the resistance. (*g*) It permits the use of operators not specially trained. It entirely removes the element of thought from the mind of the operator who has simply to operate the master switch or push button in the desired direction and does not need to think about drift points, safety features, etc.

TYPES OF STARTERS

THE 3 general types of automatic starters are:

Time element, wherein the starting resistance is cut out in a fixed period of time. This type is not adapted to conditions of varying starting load.

Counter electromotive force, wherein the starting resistance is cut out by magnets actuated by the counter electromotive force of the motor. The reliability of this system is decreased by the fluctuation in line voltage, except in the case of motors of small capacity, though it has worked well in elevator work. Figure 1 shows a connection of a counter electromotive force starter with one step of starting resistance. The contactor coil is connected in multiple with the motor armature and is so designed that the contactor will not close until the counter electromotive force of the motor has built up to a predetermined value.

Current limit, wherein the starting resistance cut out is regulated by the motor current. The current-limit type of starters are of 2 kinds: First, with shunt-wound magnet switches, actuated through series relays which will not close until the accelerating current has reduced to a predetermined value; Second, with magnetic lock-out switches (or series contactors). These series type switches consist essentially of a series-wound coil actuating the switch, the coil being in the motor circuit. The magnetic path in the switch may be so adjusted that the switch will not close until the current has reduced below a certain critical value.

A simplified wiring scheme of a series type of starter is shown in Fig. 2, in which 1 in the shunt-line contactor; 2 and 3 series accelerating contactors, and 4 a compound series accelerating contactor, with shunt holding coil and interlock in the control circuit of the holding coil. Operation of the control switch closes contactor 1; motor starts with all resistance in circuit. Contactor 2 closes as current falls to some predetermined value, short-circuiting R_1. As contactor 3 closes, due to falling off of current, R_2 is short-circuited; this contactor also

*From a paper read before the A. S. M. E.

short-circuits contactor 2 with its coil, causing 2 to open. In the same manner contactor 4 closes, short-circuiting resistance R_3 and dropping out contactor 3; in closing, contactor 4 establishes a circuit through the interlock for shunt holding coil, thus insuring that contactor 4 will stay closed until the voltage fails or the control switch is opened.

Starters for Constant Speed Motors

A starter for small motors of ¾ hp. and less, where starting resistance is not necessary, is shown in Fig. 3. It consists of a line contactor, an overload relay, a field rheostat and connection board, mounted on the insulating base and enclosed in a case adapted for conduit wiring. This starter is arranged always to start with full field on the motor by simply turning the field rheostat handle to the extreme left, thus closing the line contactor, after which the rheostat handle may be turned to the point for the desired motor speed. If desired, an "emergency stop" push button may be located at any convenient point on the machine. This starter is especially adapted for headstock motors, wood-working machines, etc.

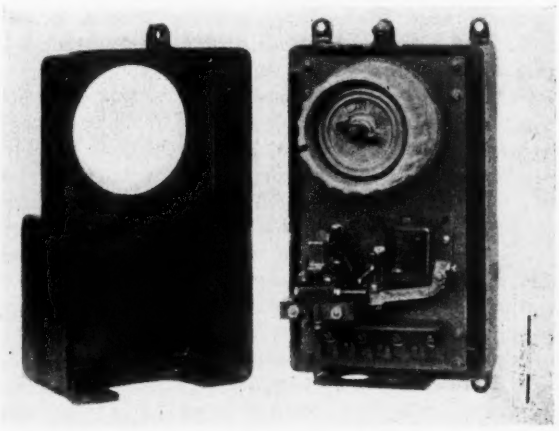


FIG. 3. STARTING PANEL FOR SMALL ADJUSTABLE SPEED MOTOR, WHEN STARTING RESISTANCE IS NOT NECESSARY

A starter for motors of ¾ to 3 hp., where one step of starting resistance is necessary, is shown in Fig. 4. The appliances on the front of the panel consist of line switch and fuses, contactor, counter electromotive force accelerating contactor, and connection board. The starting resistance is mounted on the back of the panel.

Starters for Adjustable Speed Motors

For general service, starters for adjustable speed motors should be of the same general design as described above for constant speed service. The appliances on the panel should include: double pole line contactor, necessary accelerating contactors, overload and no-voltage protection, field accelerating relay, provisions for starting motor with full field, provision for disconnecting motor fields when machine is not in use, dynamic braking contactor, when required, and protected terminal connection board.

The starting resistance should be mounted back of the panel, except in the case of large sizes of motors, when it should be separately mounted. The field rheostat should be mounted separate from the panel, with the possible exception of small sizes of motors. The method of control should be at the panel or remote, as operating conditions require.

Reversing Service

For general reversing service, the starters should be of the same general design and requirements as for non-reversing, with the following modifications: (*a*) Dynamic braking at the "off" position should be supplied to protect the motor. (*b*) Two double-line contactors are necessary to give the reversing. In small equipments, a double-pole, double-throw switch may be used for reversing.

General Service

Types of starters described above are applicable for all general service, as pumps, fans, drill presses, grinders, milling machines, and boring mills, except in cases where special features are desired.

Protective Features

All automatic starters and control apparatus should be provided with protection from low line voltage, and from excessive overload. In all cases, except possibly pumps, fans and similar machines, these protections should be of such nature as to disconnect the motor from the line, and not to be restarted except by the operator at starting station. For motors of over 25 hp. the overload protection should be preferably an overload relay, either hand or electrically reset, as operating conditions require. For motors below 25 hp., the overload protection should be fuses, chiefly for economic reasons.

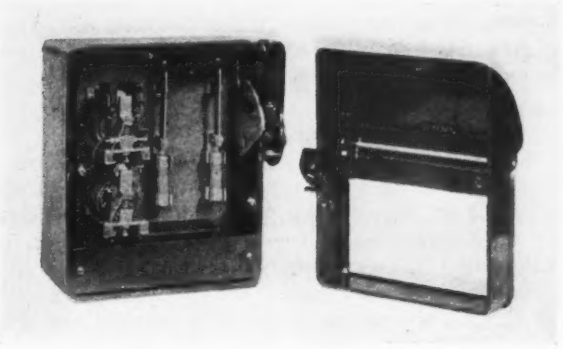


FIG. 4. DIRECT-CURRENT STARTING PANEL. MAXIMUM RATING 3 HP. AT 230 V.

With adjustable speed motors, it is often desirable to set the field rheostat so that the motor will always operate at a certain speed. To accomplish this, in motors above 5 hp. the connections should be such as to start under full field and supply a field accelerating relay, which is actuated by the motor current; and the contacts, when closed, serve to short-circuit the field rheostat. This permits starting under full field torque and prevents an excessive peak current when the last accelerating contactor closes, as the relay alternately cuts the field rheostat in and out as the motor increases from full field speed to the desired fast speed, resulting in a fairly uniform load current on the motor.

With adjustable speed motors of a range of greater than 2 to 1, provision should also be made so that the field resistance is not cut in until the last accelerating

contactor has closed, thereby cutting out the last step of starting resistance. Provision should be made so that the motor fields are not energized when the machine is not in use.

With adjustable speed motors, especially with a range of 4 to 1, arrangements should be such as to prevent a "pump back" when stopping the motor.

On work requiring quick reversing, dynamic braking should be provided at the "off" position of the starting switch. In many cases, as on planers and boring mills, a graduated dynamic braking of 2 or more points is necessary.

Resistances

In connection with starting apparatus, one of the most important items for consideration is the starting resistance. Except in cases of small motors, cast-iron grids are very satisfactory for this service. For small motors, a high-resistance wire, or ribbon, is suitable, which may be in the form of enclosed coils, flat plates or other special forms. A motor driving a load which is subject to infrequent overloads of short duration should have a resistance unit of large thermal capacity, while a motor subject to frequent overloads should have a resistance unit of small thermal capacity in order to give more rapid cooling. In all cases, the resistance units and their mounting should be of rugged construction and properly supported to be conveniently accessible.

TABLE I. NUMBER OF STEPS OF STARTING RESISTANCE REQUIRED FOR VARIOUS SIZE MOTORS

	Horsepower of Motor	
No. of Steps Directly on Line	Constant Speed Below 1 HP.	Adjustable Speed[1] Below 1 HP.
1	1-3	1-10
2	3-10	10-25
3	10-35	25-50
4	35-75	50-75
5	75-150	75-150
6	150-200	150-200

[1]With full field starting.

Starting resistance should be so laid out in the various steps as to give practically uniform acceleration peaks. In certain cases, as fans, where the load increases with the speed, it may be desirable to have the transition points tapered, the low points being at the beginning, thereby requiring less starting steps, and reducing the peak demands from the line.

The National Electric Light Association has proposed the following requirements for direct-current motors, as to maximum starting current, for 230 v., which is the average factory voltage:

3 hp., and below.....12 amp. per horsepower
Above 3 hp..... 9 amp. per horsepower

No motor may be connected without a starting resistance where the starting current exceeds 30 amp.

Table I gives the number of steps of starting resistance which should be required for general service.

Motors

Not the least important factor for a successfully operating electrically-controlled machine is the motor.

In a shunt motor which starts under constant field excitation, the torque is directly proportional to the armature current. This type of motor is applicable for machinery where constant speed is desired, as small printing presses, ventilating fans, small machine tools, woodworking machines, etc. For adjustable speed work it is applicable to planers, boring mills, heavy lathes, etc.

In a series motor, the field excitation will vary with the load, which results in a varying speed and a powerful torque at slow speed. This type of motor should always have a certain friction load and be geared or direct connected to the load in order to avoid the possibility of the latter being thrown off and the motor accelerating to a dangerous speed. This type is applicable to centrifugal pumps, cranes and hoists.

In a compound motor, the combination of the shunt and series fields produces the heavy starting torque with small variation in speed. The working speed can also be increased by means of the shunt field. This type of motor is applicable to machinery requiring large overload capacity for short periods of time, as rock crushers, air compressors, shears, large printing presses, etc.

While the control apparatus for general use must be designed to operate with a standard motor, it is necessary that designers of both motor and control appliances be in thorough co-operation—especially if the customer is to obtain satisfactory results. One of the main points to bear in mind in the application of electric control to shop tools is simplicity, not only in the design of appliances, but in the control schemes as well. This is especially true in the application to special and heavy-duty machines. This will mean that in many instances the motor will need to be designed for the purpose and have the desired characteristics as to stability, overload, commutation, etc. The control problem will then be much simplified. Indeed, many of the troubles and probable failures of electric control in the past may have been due to the complicated control applied in an attempt to have the motor perform functions of which its design would not permit.

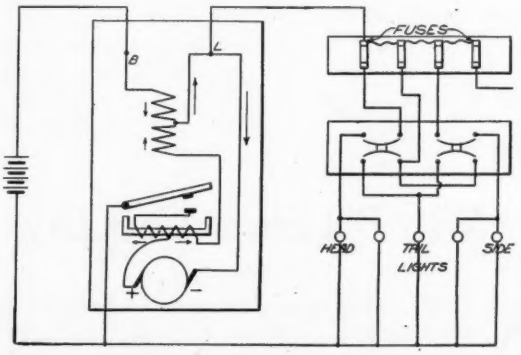
A Day's Work for a Trouble Man

The first job in the morning was a Westinghouse automobile lighting generator that would not supply current for the lamps. Often automobile starting motors and generators are brought in the shop for repair when the trouble is somewhere else, therefore, the first thing to do is to try the generator by putting it in a lathe and driving the armature from the chuck. In the diagram is shown a magnetic switch with a fine winding to the right in series with the shunt field coil. When the generator was started, the magnetic switch closed, indicating that the armature and shunt winding was all right, but no current could be had from the terminals. The machine was then taken apart and the series winding found open. When this was repaired and a test made, everything was satisfactory.

This generator is entirely automatic, taking care of the wide variation in the speed and load. From a study of the diagram, it will be seen that both the shunt and series coils on the magnetic switch and field poles are wound in opposition to each other or are differentially wound. When the generator is being driven at a slow speed, the switch is held open by a spring; when the car is going at 10 or 12 mi. an hour, the generator voltage is high enough to close the switch by the magnetic pull of the fine winding. The circuit is then closed to

the storage battery and lamps. When the generator is being driven at a high speed, the voltage is held down by the current in the series winding weakening the field. If the current should become excessive, the line will be opened by the series winding on the switch magnet neutralizing the shunt winding.

The second job was at a carpet cleaner's, where the carpets to be cleaned were piled to the ceiling. A motor man from a rival concern had been there the day before and being unable to make the belt stay on, had told the manager that he would have to have 2 new larger pulleys and a larger belt, as the present ones were too small. The motor was a 5-hp., 200 v., 20 amp., driving a large wooden drum which resembled a large horizontal washing machine as used in a steam laundry. From 200 to 500 sq. yd. of carpet are placed in the cleaner at one time, and the drum is slowly turned. The carpet falls over and over, beating out the dust and dirt which is drawn off by an exhaust fan.



LIGHTING CIRCUIT FOR AUTOMOBILE

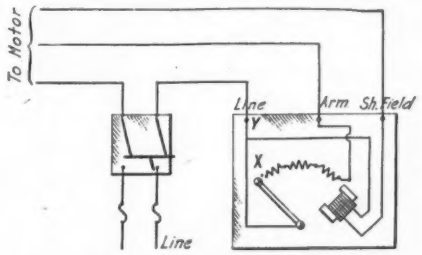
Starting the motor with the belt off, it appeared to be in good condition. An ammeter was put in the circuit and the motor started driving the fan. The current was 10 amp., and everything went well. The drum was then put in gear and the motor started. When it had reached ¼ speed, the belt came off so suddenly that it was impossible to see the cause. The belt was put on and the motor started twice with the same result, but the ammeter showed a current of 40 amp. at the time of the belt jumping off.

The drum was unloaded and the gears disengaged. It was all one man could do to turn it over. On inspection, it was found that the drum bearings were as dry as could be, the oil holes being stopped up with dust. The drum was driven on one end by a large sectional gear, these ends of the sections being held together by 2 5/8-in. machine screws. At one joint, both screws were missing, which allowed the gear to spring out about 1 in. As the drum turned, this high end came against the pinion with a hammer blow that caused the belt to come off with such suddenness.

The third and last job for the day was on a Wagner single-phase motor, direct-connected to a Spencer turbine, running at 3400 r.p.m. When the switch was closed the motor would start and get almost up to speed, as the brushes would leave the commutator the speed would decrease, causing them to come back. The speed would again increase until the brushes were thrown off a second time; again the speed would decrease. A small piece of wood was put under the brush springs to give the effect of lengthening the brush. The switch was closed and the motor started all right. A new set of long brushes were put in. It is necessary that the brushes stay on the commutator until the short-circuiting ring is in the running position. A. THOMSON.

Improving Starting Torque of Shunt Motor

IN A Southern factory where a shunt motor was required to start under considerable load the operator improved the starting torque by the change in field connections shown in the accompanying illustration. The field connection to the motor starter was removed from



CONNECTIONS THAT IMPROVED STARTING TORQUE OF SHUNT MOTOR AND RELIEVED ARCING AT STARTER

the point marked *X* and connected at *Y*. This arrangement gives full field strength at the instant the main-line switch is closed and relieves arcing at the point *X* when starting the motor. The motor now starts easily when the starter arm is on the first point of the resistance.—Electrical World.

EXPERIMENTS ON the distribution of pressures through soils are to be conducted at the Government's Arlington Farm, near Washington, by the Office of Public Roads and Rural Engineering, U. S. Department of Agriculture. A specially designed apparatus will be installed which will permit of earth pressure measurements being taken in a large number of positions during a single application of the load. This feature is regarded as an important one and it is hoped that an unnatural rearrangement of the soil from previous load applications in various positions will be thus avoided. Earth fills up to 10 ft. thick may be accommodated by this apparatus and it will have lateral dimensions sufficiently large to permit of obtaining the full distribution of the load in all directions. Comprehensive plans have been made for a practical solution of this problem and it is hoped that definite results will be forthcoming within a short time.

The uncertainty of the distribution of pressures through soils, both vertically and horizontally, has long been recognized by the engineering profession, and several isolated experiments have been made with laboratory apparatus to gain knowledge on this subject. In magnitude, the problem is such that its practical solution can be attempted only by the most thoroughly equipped experiment stations. In application, the final solution will be important to all branches of engineering, and it has seemed desirable that the Department should devote a portion of its experimental resources to a most thorough and conclusive research of this nature.

Cutting Hole in Plaster Wall for Distribution Cabinet

By A. Gorman

IN wiring finished buildings, it is necessary in practically every installation for the wireman to cut a relatively large hole in a plaster wall or partition for the reception of the distribution cabinet. If he proceeds with this work in accordance with the methods described herewith, which experience has shown to be the most effective, he will save himself both time and worry.

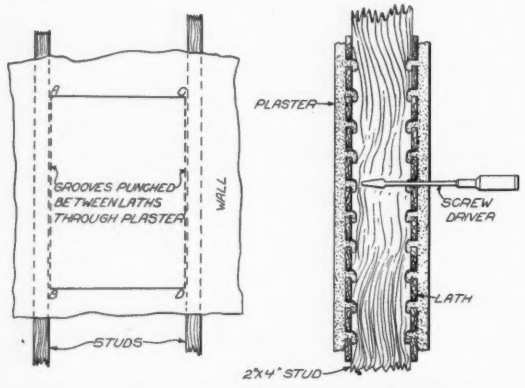


FIG. 1. PUNCHING GROOVES IN THE PLASTER

Usually the cavity or pocket for the reception of the distribution cabinet extends the entire distance between 2 adjacent studs. After the wireman has decided upon the approximate location of the distribution cabinet, a small screwdriver should be pushed through the plastered wall between 2 laths in order to determine the location of a stud, which can be previously found approximately by tapping on the surface of the wall with a hammer. The screwdriver is pushed through the plastered surface as shown at the right in Fig. 1, care being taken to get it as near as possible to the face of one of the studs

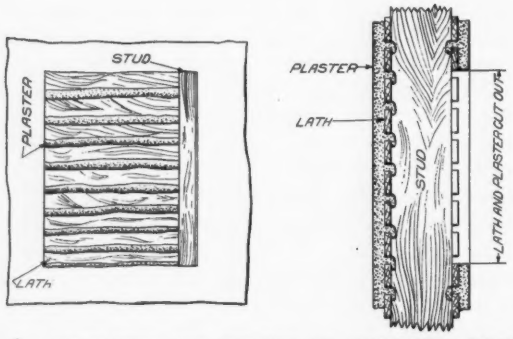


FIG. 2. ELEVATION AND SECTION OF COMPLETED POCKET

so that the screwdriver will slide into the space in the partition and lie against one of the studs. A trial or 2 may be necessary in order accurately to determine this stud location.

After the location of the face of the stud has once been determined, the wireman should punch along the stud face through the surface of the partition a series of holes for a distance equal to the length of the distribution box that is to be placed in the pocket. Another similar series of holes is pushed through the plaster along the edge of the next adjacent stud, and then a groove is made through the plaster at the top and bottom of the distribution-box location with the screwdriver. The 2 lines of vertical holes having been punched through the plaster and the 2 horizontal grooves cut, the exterior of the wall will appear as indicated at the left in Fig. 1. All the plaster within the rectangular area should then be chopped out in cakes with a screwdriver or a chisel. The laths are next cut with a compass saw along the lines *AB* and *CD*, and the pocket will appear as shown by the front-elevation and cross-sectional views in Fig 2.

The distribution box can now be fitted into the cavity *ABCD*. If the box is to be made of wood lined with asbestos or of sheet metal, it should be proportioned to fit exactly within the pocket. If a metal distribution cabinet purchased from the stock of an electrical-supply house is to be employed, the workman may find it necessary to nail spacers or battens onto the faces of the 2 studs in order to insure that the metal distribution cabinet will fit snugly when inserted in the pocket.—Electrical World.

Why Bill Burns Goes Dry

By N. Devering

AFTER the Engineer's Progress Club of Pucketyville had been called to order and the basket of apples passed around to all present, the president (usually called the Captain) announced that Uncle Dick would talk tonight, an' tell all about Bill Burns an' the water wagon.

Uncle Dick Chinary was the engineer at the handle factory; it was known to the inhabitants of Pucketyville that Uncle Dick had held a good position as chief engineer of a large power plant in a large city. It was also known that he was well educated and was a constant reader, and not in the habit of talking about himself, other than to admit that he was compelled to come to the mountains on account of failing health. He had what he called a nice "little job," caring for 2 boilers and an engine, keeping everything clean and his machinery running smoothly as the days of a happy honeymoon. He read considerable and was authority on mechanical matters for those in trouble for many miles around.

He began his narrative: "Fellow engineers of Pucketyville, I am glad to see so many of you here tonight, and I shall endeavor to explain to you how the men in a sawmill played pranks on the engineer. The result of their tricks was the making of a man from the remnants of one on the ragged edge of ruination.

"Bill Burns was a good man, and a good engineer, when sober; but the time had come when he was seldom sober, so the men in the mill decided to make him believe that his brain was getting twisted, and thereby probably scare him. Bill had been on a buster for several days, had not been near the mill and knew nothing of what was going on there.

"On Friday morning when Sam Squiggins, the mill mechanic who was working in Bill's place, opened the blowoff valve on the boiler to blow down, as usual, something lodged under the valve and it would not hold tight; it leaked so badly they were obliged to shut down for the day. So they cleaned the boiler and repaired the blowoff valve, and this is what they did on Bill." Taking a piece of chalk, Uncle Dick sketched on the blackboard (Fig. 1). "Now there is what they did to the gage cocks that were screwed in the head of the boiler, there was no gage glass, so the gage cocks served to show the water level in the boiler. They fitted short nipples in the inner ends of the upper and lower gage cocks, and attached ells and longer nipples as you see in the sketch."

Uncle Dick then sketched the working parts of a steam gage (Fig. 2).

"The boys then took the face off the steam gage and disconnected the mechanism at the end of the tube, connecting a piece of copper wire, as shown there, from the upper part of the tube to the inner side of the toothed

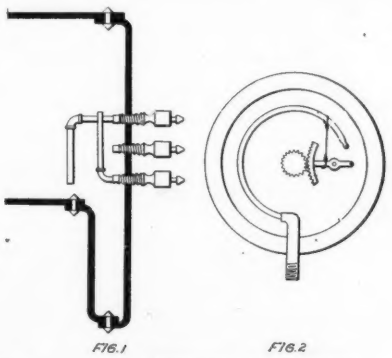


FIG. 1. BILL'S TWISTED GAGE COCKS
FIG. 2. THE CRAZY STEAM GAGE

lever, thereby causing the gage to operate the reverse way. They knew that they need operate only one day under these conditions, and if they succeeded in their labor, then the firm and Bill Burns, and his family would all be gainers, and things could be put right over Sunday.

"Early Saturday morning Sam Squiggins came out and, with the aid of another steam gage, they raised the steam pressure to 80 lb., then put the face on the main gage and set the hand, or pointer, at 80 lb., the pressure they desired for running the mill. They then removed the extra gage and kept the steam pressure close to 80 lb. The foreman had gone to Bill's home and insisted on his coming to work that day, although he did feel very sick from after-effects.

"When Bill came into the boiler room, there was 80 lb. of steam; he took the stick and struck the second gage cock, which showed 2 gages of water. Apparently satisfied, he opened the fire door and looked at the fire. They had the engine running, so Bill began to fire up. His face became very red from the heat and the exertion, so after getting the fire in the furnace in the condition he wanted it, he stepped outside for a spell.

"Returning in a short while, he noticed there was less steam, so went at the fire once more; he then thought of the water, and finding no water in the second gage, he tried the first gage; as it showed no water he ran to the injector and put it on. During this time, Sam was watching him closely from the mill, without attracting Bill's attention, as they had decided to keep close watch on him and see that nothing serious occurred.

"Bill walked about restlessly for a short time, then pushed in the lower gage cock again,—dry steam escaped; he looked somewhat frightened, but, looking up at the steam gage, the pressure appeared to be going up. He then looked at his fire, which was burning down some. Again, he took the stick and pushed in the second gage cock—plenty of water—he then tapped the top gage cock,—high water; he jumped for the injector and shut it off. He then stepped outside to mop his brow, but the mill foreman yelled at him.

" 'Fire up! Bill, she's draggin'.

"Bill called back: 'Lots o' steam, she's up to ninety.'

" 'We don't care where she's up to, Bill, there ain't steam enough,' said Eb. Hite, the foreman; 'an' what's the matter with you? You look like you had seen your grandmother's ghost.'

"Bill threw his hat over in the corner and went at firing again; by this time the steam gage showed nearly 100 lb., but the engine was dragging. By the time Bill got the fire in the shape he wanted it, he looked at the gage, which showed only 80 lb. He went and got a drink of water and returned to the boiler room, and went at firing again.

"Sam Squiggins then entered the boiler room and asked, 'How goes it, Bill?'

" 'By Hickory, Sam,' he replied, 'the more I fire the lower she goes'; the gage then showed 70 lb.

"Bill took a chunk of tobacco, threw several buckets of water in the ash pit; the gage was still traveling the down grade. He went at it again and got his fire roaring,—but the steam pressure, according to the gage, kept going down. He then went outside, mumbling to himself about the dum'd injine pullin' the insides out o' the biler.

"Bill looked up at the stack and again started for the boiler room; when he entered, the gage registered 50 lb. He reached for the poker; like a thunderbolt from a clear sky, the safety valve let go like a shot, blowing off good and hard,—50 lb. on the gage and the safety valve blowing,—and it had always let go at 110 lb. before.

"Bill dropped the poker, looked at the gage again, then went outside and looked up at the escape pipe from the safety valve.

"He looked scared and much worried, but went inside and put the injector on, then decided to try the water again. He pushed in the top gage cock—plenty of water, apparently too much—he then took the injector off again, but took the stick and tried the second gage—it was dry. 'Third gage full and second gage dry,' he mumbled; he tried the second gage again—dry steam; 'wallopin' wildcats!' he shouted, then pushed in the lower gage cock—dry steam—he tried it several times, holding it in long, nothing but dry steam escaping. He shook his head, then ran to the injector and put it on again.

"By this time the safety valve had closed and the gage showed 60 lb. Bill looked much worried and very pale. He paced about for several minutes, then tried the top gage cock again—plenty of water—he took the injector off.

"Sam Squiggins then picked up the stick and tried the second gage—dry steam—Bill stared at him. Sam then tried the bottom gage cock; it was dry, too.

"'What's the matter with you, Bill?'' Sam asked.

"'I'm sick, Sam,' replied Bill, 'an' bile me if I know what I'm a doin'.'

"Sam then put the injector on again.

"Bill said: 'By gum, Sam, when I fire her up the steam goes down, then when I see only 50 lb. on the gage, the blamed safety valve blows off. An' the water in that biler must be crazy today—if I put the injector on the water seems to go down, or else there's water in the top gage when there's none in the bottom; she must be upside down, or else I am.'

"'Everything's all right here, Bill,' Sam replied, 'but there seems to be something queer about you today; you don't seem natur'l like yourself.'

"'Is that so?' Bill asked.

"Sam told him he thought the apple jack had just about got the best of him, and he didn't think he would be fit to fire the boiler any more. Bill was getting pale and flushed in turns, and showing signs of breaking down.

"'You'd better go home an' fix up your business an' tell your family goodbye, Bill, an' I'll get another man in your place, for you're not fit or safe to have around here.'

"'By Jinks, Sam, the way things are going here, I'm crazy or the boiler is. An' I'm goin' home to quit the apple jack an' whisky, an' darn my socks if I don't come back here an' run this place, an' run it right.'

"He grabbed his hat and coat and looked at the steam gage, which showed 90 lb.; he headed for the door, calling back to Sam: 'Keep her right till I git right.'

"That night Sam put the steam gage and gage cocks in proper condition.

"In 2 weeks Bill was back at work; he has been on the water wagon ever since, and he now holds the position of chief engineer in a good sized mill."

Ten Things to Do*

1. INSTALL a Strainer ahead of Pressure Regulators.

2. Connect your Water Column to the boiler with Brass Pipe and Fittings. Make provision for cleaning out.

3. Use properly designed Air Cocks on your High Pressure Air Lines.

4. When valves and fittings are wanted for compressed air, say so on your order or inquiry.

5. Buy Steam Traps on their discharging capacity—not by pipe sizes.

6. Water seal your Exhaust Relief Valves.

7. When Cocks are wanted for steam lines, use all Brass or all Iron.

8. Use O. S. & Y. Gates between boiler and header.

9. Use O. S. & Y. Gates between the water column and the boiler.

10. When the discharge opening of Pop Safety Valves is piped up, make the piping the next larger size.

*Suggested by the Mechanical Expert's Department of Crane Co.

Protecting Side Wall of Furnace

DETERIORATION of furnace lining is most severe just above the grates at the sides of the furnace. This is due to high temperature resulting in fusing of bricks, and the formation of clinkers causes pieces to be broken off. Other causes include contraction and expansion with changes of temperature and abrasion from fire tools. To lengthen the life of furnace walls, Charles M. Crewe describes, in the Electric World, a method of construction which he has used which has given 5 yr. of service with no expense for repairs.

In the construction illustrated, 2 discarded herring-bone grate bars 6 in. wide with ⅜-in. air spaces were used, one at each side wall. These grate bars were set so as to bring the face of the grate flush with the fire-

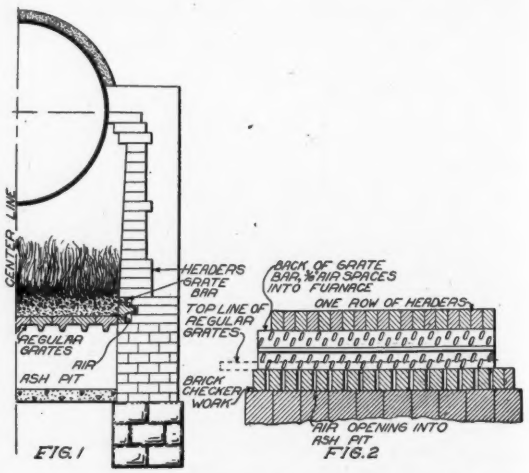


FIG. 1. SECTION OF FURNACE SHOWING SPECIAL SIDE WALL CONSTRUCTION AND RELATION OF FIRE

FIG. 2. BACK OF GRATE USED IN SIDE WALL

brick lining. A heavy type of grate bar is required and to prevent warping and burning out, the lower edge is set slightly below the top surface of the regular grates and rests on a checker-work of brickwork opening into the ashpit. This construction allows air to pass around the back of the grate bar from the ashpit, then through the grate bar into the furnace.

When the fire is being cleaned the face of the grate bar so installed takes all the wear resulting from the use of slice bar and hoe, and if properly placed little difficulty will result from clinkers. The clinkers show no tendency to attach themselves to this surface. The only precaution necessary is to favor the sides of the firebox with extra fuel directly after cleaning and while the fire is light in order to prevent an excess of air over the fire.

This construction operates like regular grates; that is, if kept covered there is little tendency for them to burn out. There will be, however, a certain amount of combustion taking place along the face while the fire is new, due to air coming through from the ashpit. When the fire has thickened sufficiently, the ash comes in contact with this construction, which, together with the air that filters through, forms a protection.

Jackets for Gas and Oil Engines

Consideration of Most Economical Temperature Range of Cooling Water.

By Reginald Trautschold

INTERNAL combustion engines, whether operated on gas or oil fumes, have proved such valuable and economic prime movers in many instances that under certain conditions they are to be preferred to the more generally used steam engine of the reciprocating or turbine type. This means that the economic conditions of the day make it imperative that the thermal efficiency of such engines be developed to the highest practical degree. Already the efficiency attained by engines in which the fuel is consumed in the cylinder is higher than has ever been secured for engines depending upon the pressure and expansion of a medium such as steam. The efficiency of the internal combustion engine as built today is materially better than that of the steam engine. To improve still further the efficiency of gas and oil engines is, then, of chief importance if these engines are to continue to encroach upon the field so long monopolized by the steam engine.

TABLE I. RESULTS OF TESTS FOR FUEL CONSUMPTION

Fuel Consumption per horsepower-hour	Temperature Discharged Water	Jacket Water Temperature Range
17,000 B.t.u.	110 deg. F.	52.0 deg. F.
16,250	116	53.0
15,250	118	53.5
14,300	120	54.0
13,900 B.t.u.	100 deg. F.	55.0 deg. F.
12,650	110	57.5
11,400	120	62.5
9,250 B.t.u.	148 deg. F.	73.5 deg. F.
8,100	163	86.5
7,750	176	103.0
6,000	185	111.0

High efficiency of the internal combustion engine has only been secured gradually. Much progress has been made in the use of suitable mixtures of fuel and air, in the design of the engines, in their regulation, etc., etc., during the past few years, all of which have had the effect of improving efficiency. Continued improvement along these lines is to be expected and desired; but the most fruitful field of improvement would seem to be in the jacketing of such engines—a phase of the subject the importance of which seems not yet to have been generally recognized.

The efficiency of a steam engine is controlled to a large extent by the temperature of the cylinder walls, and the higher this can be maintained the better, as a rule, the efficiency. Preventing the cylinder walls of a steam engine from cooling sufficiently to produce serious cylinder condensation tends to increased efficiency, as is evidenced by the results secured by "uniflow" engines. In the case of the internal combustion engine, on the other hand, efficiency is promoted by a reduction in the temperature of the cylinder walls. This is necessary as a precaution against premature explosions and to safeguard the cylinder against the high temperatures which are developed within it by the combustion of the fuel. The jackets of steam engines and internal combustion engines are installed then for diametrically opposed objects.

Purpose and Efficiency of Water Jacket

Jackets of internal combustion engines must possess the capacity of absorbing the maximum amount of heat and the ability of conveying this heat from the cylinders—that is, the jacketing material must be withdrawn from contact with the cylinder upon becoming hot. Obviously this necessitates a liquid jacket, and for practical considerations of cost and supply the liquid almost universally employed is water. This has a higher specific heat and therefore greater heat absorbing capacity than any other inexpensive liquid and is readily procurable, as a rule.

The efficiency of a water jacket depends upon its temperature and, as obviously the temperature of the jacket water cannot be the same on admission to the jacket as on its discharge after absorbing heat from the cylinder, this means 2 temperatures must be considered—that of the water on entering the jacket and that on its discharge. The natural assumption would be that the water should be admitted to the jacket at a low temperature and should also be discharged while still comparatively cool, so that the heat absorbing capacity of the water may be at a maximum. Logical as this assumption appears, it is not borne out to any very noticeable degree in practice.

TABLE II. JACKET WATER REQUIREMENTS FOR 25-HP. ENGINE

Jacket water temperature range = 105 deg. F.

Thermal efficiency at full load = 30 per cent.

Load	Horsepower developed	Jacket water required to maintain relative efficiency
Full	25.0	76.0 Gal. per hr.
7/8	21.9	73.0 " " "
3/4	18.8	70.0 " " "
5/8	15.6	68.0 " " "
1/2	12.5	61.0 " " "
3/8	9.4	81.0 " " "

Heat transfer between 2 bodies depends upon their difference in temperature. The maximum temperature in the cylinder of an internal combustion engine is from 1500 to 2000 deg., or even more, while the mean temperature is between 900 and 1100 deg. F. The minimum practicable temperature of the jacket water is about 35 deg. F. The difference between this temperature and say 1000 deg. F. as the average mean temperature in the engine cylinder is so great that a few additional degrees of heat to the jacket water on admission to the jacket makes practically no difference. In fact, there is less than 3 per cent difference in the efficiency of a water jacket about an internal combustion engine between one having an initial temperature of 35 deg. and one of an initial temperature of 80 deg. F., which, as will be seen, is about the maximum allowable temperature for jacket water on admission to an efficient jacket.

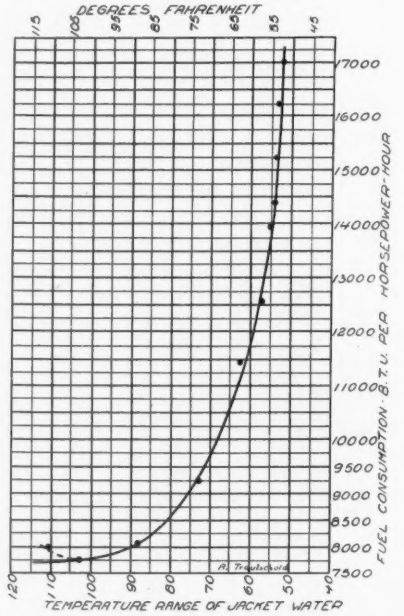
Discharge temperature of the jacket water then takes on added importance on account of the negligible admission temperature, but is limited to a maximum of about

180 or 190 deg. F., for at any higher temperature the generation of steam on the side of the jacket next to the hot cylinder wall becomes sufficiently serious appreciably to reduce the efficiency of the jacket—the specific heat of steam at atmospheric pressure being less than ⅓ that of water.

Effect of Temperature Range

Difference between the admission and discharge temperatures, the temperature range, of the jacket water has a marked effect upon the efficiency of the engine, however, as will be seen by a glance at Chart I. This curve is plotted from the data of Table I, which gives the average results of tests performed on several internal combustion engines operating on fuels of approximately the same heating value. These tests were conducted to

CHART I. TEMPERATURE RANGE OF JACKET WATER AND FUEL CONSUMPTION



ascertain the fuel consumption of the engines under full load conditions and were made without proper attention being paid to the jacket water supply, other than the recording of temperatures. The initial temperature of the cooling water was about the same in the majority of runs, though in a few instances there was considerable variation.

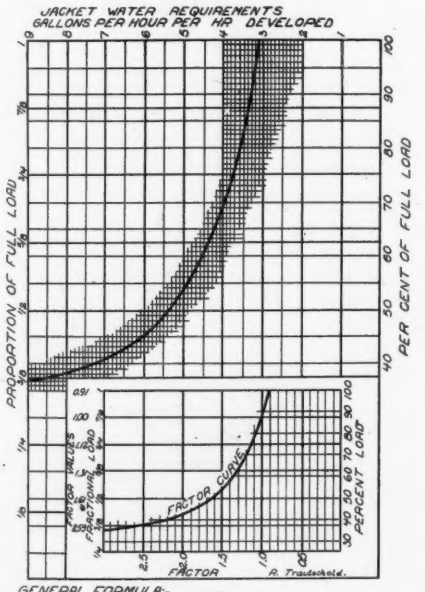
Close approximation of the actual readings to the smooth curve show conclusively that the temperature of the jacket water on admission has really little effect upon the efficiency of the engine. The curve shows conclusively, however, that the temperature range has an important effect on this question. The beneficial effects are seen to approach closely a maximum when the temperature range is one of about 105 deg. F., so that there is really little gain in efficiency to be realized by the use of jacket water having an initial temperature of less than 80 deg. F., though any higher temperature might seriously affect the efficiency through the excessive generation of steam in the jacket before the water had passed through the economic range of 105 deg.

From Chart I it is seen that the highest efficiency attained on the tests was about 33 per cent, a record considerably better than would be obtainable by any kind of steam engine, but this record necessitates operation under full load conditions. Operating under fractional loads—that is, loads less than the rated capacity of the engine—entails a supply of relatively greater volume of jacket water for the fuel consumption of the engine is not proportionally as economical under the lighter loads—the attainable efficiency is less. This results in the generation of more heat, which is unavailable for conversion into useful power and therefore more heat which should advisably be absorbed by the jacket water. Under full load conditions, about 30 per cent of the heat generated by the combustion of the fuel charge is usually absorbed by the jacket water, and under lesser loads advisably considerably more.

Jacket Water Requirements

The jacket water requirements for a 25-hp. internal combustion engine operating under various degrees of load are tabulated as Table II. The thermal efficiency of the engine at full load was 30 per cent and, of course,

CHART II. JACKET WATER REQUIREMENTS OF INTERNAL COMBUSTION ENGINE OPERATING AT 30 PER CENT UNDER FULL LOAD


JACKET WATER REQUIREMENTS
GALLONS PER HOUR PER HR DEVELOPED
PROPORTION OF FULL LOAD
PER CENT OF FULL LOAD
FACTOR VALUES
FRACTIONAL LOAD
FACTOR CURVE
PERCENT LOAD
FACTOR
R. Trautschold.
GENERAL FORMULA:- Q = 105 FH / (185-0)E
WHERE,
Q = GALLONS OF JACKET WATER REQUIRED PER HOUR
F = FACTOR OBTAINED FROM CURVE
H = HORSEPOWER DEVELOPED
L = TEMP OF JACKET WATER SUPPLY- DEG. FAHRENHEIT
E = THERMAL EFFICIENCY OF ENGINE UNDER FULL LOAD

less for the various conditions of fractional load and the jacket water range was kept at 105 deg. F. Chart II graphically depicts this data reduced to the common base of jacket water required per horsepower. The smooth curve showing the relationship between the number of gallons of jacket water required to maintain constant the temperature range of 105 deg. under the various degrees of load obviously has a definite equation which may be expressed as:

$$Q = \frac{FH}{E} \qquad \text{Formula I.}$$

Where

Q = Gallons of jacket water required per hour.

H = Horsepower developed—in the case of the curve = 1.

E = Thermal efficiency of engine at full load.

F = Factor obtained from the curve.

The same relationship could be as well and perhaps more logically expressed by using the specific efficiency value for each different degree of load and modifying the factor, F. The relationship is more conveniently expressed as given, however, for the variation occurring in the efficiency can be taken care of in the variable factor, F, just as accurately, thereby limiting the variables of the equation to one instead of two. Formula I is then generally applicable to any internal combustion engine in which the jacket water temperature range is 105 deg. F.

The temperature range being limited by a maximum temperature of about 185 deg. F., the initial temperature of the jacket water may be as high as 80 deg. F. without sacrificing any appreciable engine efficiency. A greater temperature range would sacrifice no efficiency either, provided the discharge temperature of the jacket water did not exceed the 185 deg. limit, and would obviously result in a decreased consumption of cooling water, as it would be possible to retain the water in the jackets for a longer period before the generation of steam became serious.

In localities where water is expensive, it is customary to use the same jacket water supply repeatedly and in such cases the fact that water with an initial temperature of 80 deg. is just about as efficient as cooler water for jacketing internal combustion engines acts as a considerable economy.

In other localities, water may be so cheap that it can be wasted with impunity—simply allowed to drain away from the jackets. In such cases, it is obvious that the cooler the supply the greater temperature range in the jackets which can safely be maintained. For instance, should the water supply temperature average 40 deg. F., it would not be conducive to economy to discharge it from the jacket at 145 deg., simply maintaining the economic temperature range of 105 deg. It could be retained in the jackets until it had reached a temperature of 185 deg., passing through a temperature range of 145 deg. without sacrifice of engine efficiency.

When the economic temperature range can be greater than one of 105 deg. F., the saving in jacket water consumption is proportional to the ratio of 105 to the difference in temperatures of the jacket water on entering and on leaving the jacket, so that Formula I takes the form of Formula II. This latter formula is applicable to any conditions, even should the temperature of the entering jacket water be slightly higher than 85 deg. F.

$$Q = \frac{105\,FH}{(185 - t)\,E} \qquad \text{Formula II.}$$

Where

Q = Gallons of jacket water required per hour.

H = Horsepower developed.

E = Thermal efficiency of engine at full load.

F = Factor obtained from curve on Chart II.

t = Temperature of entering jacket water—degrees Fahrenheit.

The varying quantity of jacket water required for differing conditions of load is forcibly emphasized by the following typical examples. The figures inserted between brackets following the jacket water requirements as ascertained by the use of Formula II, indicate the number of gallons which would be required were the demand controlled by the amount of power developed by the engine—practice which is actually resorted to in not a few actual instances—and clearly point out the wastes which are entailed when such regulation is resorted to, due to the serious generation of steam in the jackets brought about by the inadequate water supply. Maintaining constant the supply of jacket water at that required for full load operation is a more economical practice, but this entails the waste of considerable water and, unless the initial temperature of the supply is low, would have a tendency to reduce efficiency by inability to maintain a temperature range of at least 105 deg.—the surplus water reducing the temperature range of the supply to the jacket.

Example 1.

A 20-hp. gasoline engine operates on 1 lb. (about a pint) of gasoline per horsepower-hour at full load, the jacket water supply averages 65 deg. F. and the heating value of the gasoline is 18,000 B.t.u. per lb. Required the jacket water requirements for various engine loads to secure the best efficiency.

$E = 2545/18{,}000 = 0.14 \qquad (185 - t) = 120$

At full load $Q = 105 \times 0.91 \times 20.0/120 \times 0.14 = 113.7$ gal.

7/8 $= 105 \times 1.00 \times 17.5/120 \times 0.14 = 109.5$ gal. (99.4)

3/4 $= 105 \times 1.12 \times 15.0/120 \times 0.14 = 105.0$ gal. (85.3)

5/8 $= 105 \times 1.31 \times 12.5/120 \times 0.14 = 102.1$ gal. (71.0)

1/2 $= 105 \times 1.61 \times 10.0/120 \times 0.14 = 100.5$ gal. (56.9)

3/8 $= 105 \times 2.59 \times 7.5/120 \times 0.14 = 121.5$ gal. (42.7)

Example 2.

A 100-hp. oil engine operates on 0.6 lb. of crude oil per horsepower-hour at full load, the jacket water supply averages 70 deg. F. and the heating value of the crude oil is 19,000 B.t.u. per lb. Required the jacket water requirements for various engine loads to secure the best engine efficiency.

$E = 2545/19{,}000 \times 0.6 = 0.223. \qquad (185 - t) = 115$

At full load, $Q = 105 \times 0.91 \times 100.0/115 \times 0.223 = 371$ gal.

7/8 $= 105 \times 1.00 \times 87.5/115 \times 0.223 = 358$ gal. (324)

3/4 $= 105 \times 1.12 \times 75.0/115 \times 0.223 = 343$ gal. (278)

5/8 $= 105 \times 1.31 \times 62.5/115 \times 0.223 = 335$ gal. (232)

1/2 $= 105 \times 1.61 \times 50.0/115 \times 0.223 = 329$ gal. (186)

3/8 $= 105 \times 2.59 \times 37.5/115 \times 0.223 = 397$ gal. (139)

Regulating the jacket water supply so as to secure the best results is not as complicated as it would be assumed at first, for this is done automatically by simply maintaining constant the temperature of the discharged jacket water. All that is required is an accurate temperature regulator actuated by a diaphragm valve.

Much dissatisfaction may be avoided and much fuel saved by maintaining the discharge temperature of the jacket water in the neighborhood of 185 deg. F.

LETTERS DIRECT FROM THE PLANT

Cash Paid For Ideas Accepted. Sketches Desirable.
We Make The Drawings

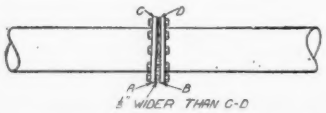
Cause of Packing Failures

N. G. NEAR'S article on the cost of poor packing suggests another element which enters into the cost of good, medium and poor packing, also the cost of excessive friction, that is the man behind the wrench.

All packing looks alike to some engineers, and if a gland spurts a little water or steam when starting up cold, it has to be tightened, sometimes until the packing hugs the rod so tight that all the lubricant is burned out of it and the air in the engine room smells as if a large rubber belt were slipping badly.

At one time I hired out to run a 500-hp. Corliss compound which was run 24 hr., 6 days a week. The company employed 2 engineers and a chief.

The first week I was on the job, the packing blew out of the high pressure piston rod stuffing-box, causing a shut-down, which I thought did not look good; but the rod was badly scarred and the hole in the front head which the rod passed through was badly worn. The chief told me it was a common occurrence and asked me if I could recommend a good packing which would last a week.



JOINT WHICH CAUSED GASKET TO BLOW

I had been used to a wedge packing on my last job, special on the high pressure and regular on the low pressure, and as it had given good satisfaction, I told him to get Daniel's PPP.

He got a box and I put it in on Sunday, as instructions come in every box; I did not tell the engineer on the other shift. We changed shifts; he took the day shift and the newly packed high pressure piston rod, with the box ⅔ full and the gland finger tight. When he started up, it started to blow, and he took the wrench and tightened it up and then tightened it some more, with the result that when I came on at 5 o'clock in the afternoon and loosened the gland it was too late to save the packing; it had been ground to pieces and, of course, blew out.

We ran all week with it blowing, and the following Sunday the other engineer packed it and cut it a good fit for the rod. He did not trim off the wedges when he bent it around the rod; when it got hot and expanded, it might as well have been a mass of hemp as far as the working of the wedges and roller was concerned. Consequently, it blew all the next week.

I packed it the next Sunday, came in Monday and gave it all the attention I could, and the packing lasted 12 weeks with the addition of 2 rings, it was not blowing and had had no tightening when we took it out.

A friend of mine had trouble keeping a flange joint, on an 8-in. high pressure main, tight. His joint was as shown in the sketch. The distance between A and B was ⅛ in. greater than the distance between D and C, and that ⅛ in. had spoiled the reputation of half a dozen good packings around that plant, and wherever that friend of mine could spread the news.

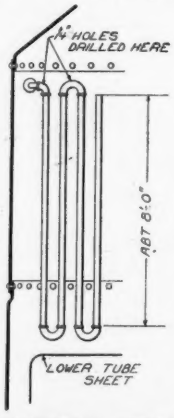
I cleaned the joint, put in the packing and tightened up the bolts on the A B side as tight as I could get them, then tightened all around. That was a year ago, and the packing is still there. J. H. ARMSTRONG.

A Boiler Feed Puzzle

AT ONE TIME, there was experienced no little annoyance on account of a seeming reluctance of certain boilers in a battery to take feed water.

There were 21 of the vertical tubular type, 17 straight shell, with manholes, and 4 of the Manning form. It was with the straight shell boilers that the trouble was had.

The trouble was at first puzzling in that difficulty would be had with one boiler at one time and perhaps the next time with 2 or 3 in another part of the room, and in order to get feed water to enter at all, the feed line pressure had to be raised considerably above normal.



ARRANGEMENT OF INTERNAL FEED PIPING WHICH GAVE TROUBLE FROM AIR BINDING

It was a popular theory that there was some obstruction in the feed pipes like sediment or mud, which the increased feed pressure would force along and free the pipe, after which all would go well for a day or perhaps several days.

When the writer took charge of the plant, it was an almost daily occurrence to have partly to close feed valves on other boilers and force the feed to one or more obstinate boilers.

At first, little attention was paid to it, the belief being that a portion of the trouble lay in over-anxiety to see the water rise in the glass when it had got near the bottom; but after a time, it became evident to me that there was really some obstacle to the flow of water at these times. Still, it seemed rather peculiar that once the flow was started, no more trouble was experienced for some time, perhaps till the next day, or for several days, with any particular boiler, though one or more was about sure to be on the balk in the early morning.

Reference to the sketch will show the arrangement of the internal feed pipe in the 17 straight shell boilers, and once the hint is given, it seems altogether absurd that the trouble should have existed so long without the remedy suggesting itself to us.

Drilling a ¼-in. hole in the elbow and each upper return bend to allow the air entrained in the feed water to escape, instead of accumulating, did the trick.

The feed pumps would sometimes lose the water at night, when the supply was scant, and thus take in some air; this would go along to one boiler or another, and when conditions were just right, partially fill the internal pipe and remain. Then, in order to get it forced down the descending leg against the weight of water in the ascending leg, the increased feed pressure on that particular boiler was required. CHARLES L. WARE.

Auxiliary Steam Line Layout

IN ORDER to overcome some bad features such as rigid connections, improper drainage, leakage and water hammer and to provide a supply of steam for heating, blowing tubes, pumping, etc., after the main generating units had been shut down the original boiler-room installation as shown in Fig. 1 was changed to that illustrated in Fig. 2.

The plant in question is in operation from 7 o'clock in the morning until 6 o'clock in the evening, and in order to supply steam for heating and that used by the watchman for blowing tubes, pumping, etc., it was necessary to leave steam on the main header up to the throttle valves of the engine, a practice which proved to be anything but economical.

To provide proper expansion and drainage of condensation a 6-in. loop or return bend was placed between the main header and the stop valve on boiler 1, replacing the rigid connection A of Fig. 1. This has amply taken care of all expansion. In order to drain the water pockets over the stop valves and the dead end of branch to heating system—B, C and D, Fig. 1—½-in. drain pipes were tapped into the former and carried in to the ash pit so that, by leaving the valves in these pipes cracked, the accumulated condensation can be continually removed. A small trap discharging with the feed water heater cares for condensation which may collect in the branch leading to the heating system.

Some engineers may object to the type of expansion joint employed; but, due to the limited head room between top of boilers and ceiling and the fact that the 6-in. main was made up entirely of screwed pipe and fittings, it was almost impossible to employ a method other than this. The fact that the main is perfectly free to expand at the engine room end, and that it is not of great length accounts for the good results being obtained.

For the supply of steam after working hours, the 2½-in. plugs were removed from the bottom of one of each pair of safety valves and connected to the pump header in engine room as Fig. 2 illustrates, branches being provided in connection with tube cleaners and heating system. This auxiliary line is always kept under pressure and on account of its small size and short run does not cause any appreciable loss.

In the morning before opening boiler stops the main header is warmed up by steam from the 1-in. connection. The stop valves can then be opened. When shutting down for the night, the stop valves may be closed and the main drained.

In case but one boiler is in operation and there is a demand for 2, the auxiliary connection may be opened, allowing the steam to enter the disconnected boiler and thereby help establish a pressure equal to that on the

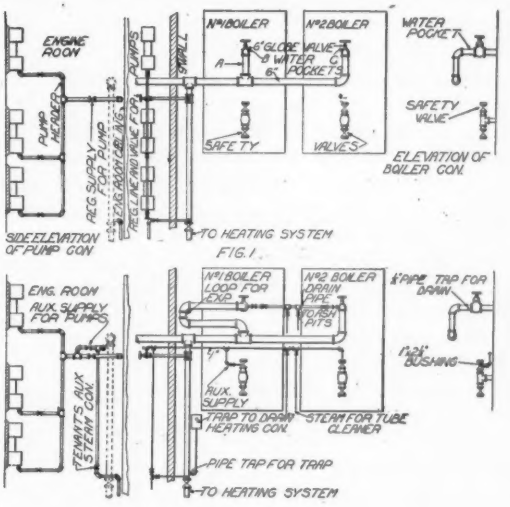


FIG. 1. LAYOUT OF ORIGINAL INSTALLATION

FIG. 2. LAYOUT OF BOILER ROOM AFTER CHANGES HAD BEEN MADE

going unit. After the pressure has been equalized the incoming boiler may be cut in without disturbance.

Another advantage introduced by the use of this auxiliary connection is the elimination of the dangerous method of carrying a steam pressure of 100 lb. on one side of the stop valve and a water pressure of 169 lb. on the bottom side of the stop-valve disk as is done when conducting hydraulic tests. CHAS. M. CREWE.

[The practice of connecting an auxiliary steam line to bottom of safety valves as is done in this instance is one not to be recommended. When the matter was referred to Mr. Crewe he stated "there was no other place without tapping into the boiler proper. . . . and fail to see any serious reason in our case why it should not be used."—EDITOR.]

AT VARIOUS times the question has arisen as to the inductance of a circuit of incandescent lamps with spiral filaments. It has recently been stated by engineers of the National Lamp Works that the power factor of these lamps is 99.9999 per cent. This would indicate that a circuit of these lamps is practically non-inductive.

Jumpers on Armature Coils; Direct Current Ammeter Action

In regard to the replies to questions in the Jan. 15 issue, the writer wonders whether the heating of brushes, in case half the coils of the motor were cut out by jumpers, would not be as much due to increased armature current as the sparking on the commutator. It would be inadvisable to cut out half the coils of an armature; but the writer has known of armatures giving good service over a long period, with 1/10 or even ⅓ of the coils cut out.

The number that may be safely cut out depends on the connection of the armature. If it is series connected, or is parallel connected without equalizers, more may be cut out than in a parallel connected armature with equalizers. Unless one understands thoroughly the connection of his armature, it is best not to use a jumper to cut out coils, as a mistake in placing the jumper may cause the burning out of more coils.

As to the action of the direct current ammeter, the indication depends not only on the strength of the permanent magnet, but also on the current flowing through the coil of the ammeter. This current is determined by the voltage drop over a resistance called a shunt placed in the main circuit, the voltage drop being 50 millivolts or less to give the full reading of the scale, so that the current flowing through the meter coil itself is very small. The coil or armature of the ammeter moves between the poles of the permanent magnet, and if this magnet loses part of its strength, the meter will not register correctly. Its loss of magnetization may be due to placing the ammeter too close to a conductor which carries a large alternating current, or to putting the ammeter in any other strong alternating current field; but for a switchboard instrument, there would not be likelihood of being exposed to such conditions. If the meter and shunt are properly connected in the circuit, the only damage resulting from a reversal of polarity of the current would be to bend the pointer of the ammeter. If the shunt was loosely connected in the circuit, or if the connection between shunt and conductor was not clean, the voltage might become high enough to burn out the current coil in the ammeter. W. E. S.

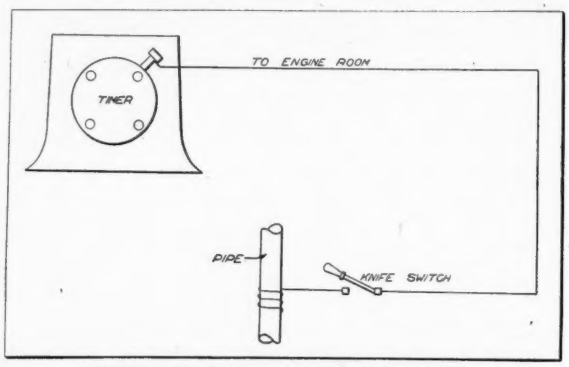
Stopping Device for Auto Engine

Recently I had occasion to call upon an engineering friend of mine. My business kept me there during the noon hour, and I was impressed by his method of shutting down his plant, which was as follows: First, he would blow the whistle, then shut down a large Corliss engine and a smaller high-speed unit, after which he would sprint the length of the shop, climb a short flight of stairs, and shut down an auto engine that was driving a fan.

To anyone that was not posted as to the reason for this sudden departure from the engine room, the matter was somewhat disconcerting, to say the least. After a quick look around, I decided to step outside until the dust had settled. With the return of the engineer to the engine room, my confidence was restored, and an explanation was in order. It seemed that this gas engine, which, by the way, is a common auto engine, was right over the main office, and the "O. M." was much opposed to its running a second longer than it had to after the rest of the plant was shut down.

After looking the installation over, I suggested running a wire from the magneto to the engine room and grounding it to some pipe. The method of wiring this simple stop, or cutout, is shown in the sketch.

This is the method used to stop auto engines on a great many cars; but unfortunately a number of engineers still do not take the interest in automobile mechanism that they should, as this line of work is gradually becoming a part of our work.



WIRING OF MAGNETO TO STOP ENGINE

I find today that the employer wants an engineer that can keep his car in repair, and sometimes 2 or 3 trucks, hence it is up to me to be able to do this work, if I want the job. A. D. Palmer.

I Don't Know

A coming young engineer faced the chief engineer. He was looking for work. The chief engineer wanted an assistant and had been advertising for one. The youngster had read the advertisement and applied for the job. The chief was a kindly but shrewd old fellow. He scrutinized and questioned all applicants closely. Thus far he had not found the man. Beginning his usual list of queries he asked in a tone that emphasized the importance of the work that had to be done: "What vacuum would you use in operating this plant?"

"I don't know," the young fellow responded.

After a grunt the chief continued, "What would be the best pressure?"

"I don't know."

"What piece or pieces of apparatus do we need in order to produce better results?"

"I don't know."

"Should any of our machinery be scrapped to make way for newer and later types?"

"I don't know."

To nearly every question the coming engineer replied, "I don't know." He was neat, clean, erect, and his face and manner bore expressions of absolute honesty. He said, "I don't know," in a clear, unashamed, unquivering voice. It was quite evident to the chief that there was good meat in this young man and the chief was pleased. He wanted solidity and backbone in his assistant. He didn't want a "guesser" or "assumer" or "maybe-ist."

The young man had with him letters of recommendation from former employers written directly from the

heart and not merely by the hand. Between the lines and between the I-don't-know answers the chief recognized a diamond in the rough. The 5 yr. of experience that the coming man had had in power plants and around machinery had not turned his head. He did not pretend to know-it-all, as had the previous applicants.

The chief now has an assistant in whom he takes great pride. The young fellow made good from the start for he proved that what he knows he KNOWS WELL. N. G. NEAR.

(Mr. Near does not go far enough in his narrative to give the proper attitude in applying for a position. All the questions cited should be answered as was done by this applicant, but there are many questions which a chief may ask which require a definite and positive answer and the applicant must recognize between what he should know and what he could not be expected to know.—Editor.)

Slotting Foundation Bolts

I HAVE FOUND that cutting a slot the width and depth of the thread on large foundation bolts and similar pieces parallel to the bolt axis, from the head of the bolt or the end of the threaded portion, to the end of the bolt or all but the last 4 or 5 threads, will make the nut work easier and does not decrease the shearing strength to any extent. In a test of several bolts of ⅝, 1½ and 2 in. it was found that by slotting the bolt, the nut could be tapped with less clearance, with a greater shearing strength than the bolt not so slotted and that when using standard tapped nuts the shearing value in the slotted bolt types was nearly equal to the non-slotted bolts. The slotted bolt can also be screwed into a tapped hole that is entirely too dirty or gritty for a standard stud to be screwed into. The slot also allows complete lubrication of the bolt while putting in a hole. In the bolts tested, the slots were cut in as follows:

⅝-in. No. 20 B. & S. saw slot.
1½-in. No. 17 B. & S. saw slot.
2 -in. No. 14 B. & S. saw slot.

Depth was equal to the depth of the threads in one test and twice the depth in another. The first-mentioned depth stood up the best in all cases. The second-mentioned depth is only recommended for very deep studs where hole is not clean. H. E. WEIGHTMAN.

Cooling System for Turbine Bearings

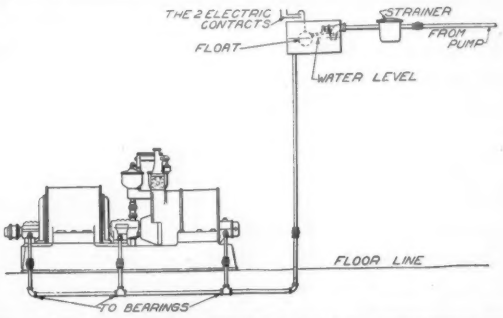
A SUBSCRIBER, operating a 1000-kw. horizontal turbine, recently asked how to install a reliable water cooling system for the main bearings.

We have just such a turbine, and had to depend upon an unreliable duplex pump to furnish water to the bearings. We realized that it would be negligent to take chances of depending on that, and possibly burn out the bearings, as the machine is a wonderful piece of apparatus, and destined to give many years of excellent service if well cared for.

The G. E. or other large manufacturers do not install the water cooling system when they set up an engine. The purchaser must see to that end of it, and pipe it up to whichever source of supply he thinks best suited for the purpose.

A simple scheme we devised to accomplish this end was to place a common water-closet water-tank against the wall at a height of about 12 ft. Water flowing therefrom has sufficient head to circulate through the bearings. We inserted a small strainer in the line from the pump to the water-box to assure the float-valve freedom from obstructive particles.

On top of the float we soldered a short stiff insulated wire in such a way that should the pump fail from any cause, 2 electric contacts would come together, ringing an alarm. Our attention called, we immediately turn on water from another source until the trouble with the pump is remedied.



TANK ABOVE TURBINE CONTAINS ALARM NOTIFYING STOPPAGE OF PUMP

I presume the engine could keep on running 5 min. that way without melting the bearings; but let us take no chances.

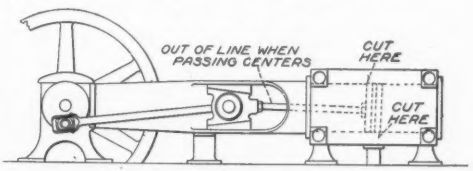
Of course, there are many ways in which an unbroken flow may be accomplished. Especially so where a number of pumps are in continuous operation during the time the turbine is running. Connecting a small branch line from every pump, with a check valve on each, is the final word in the assurance of a reliable supply.

L. M.

Wristpin Adjustment

OWING to the nature of the work on the wristpin, it will stand tremendous abuse in the way of improper lubrication and too tight keying before it will give signs of distress.

An engineer keyed up the wristpin so tight that the pin acted as a fulcrum over which the connecting rod moved one end of the piston rod, causing the piston severely to cut the cylinder and yet, due to the gravity supply of oil, the pin gave no signs of trouble.



EFFECTS OF TOO TIGHT WRISTPIN BOX

The cylinder was rebored and a new piston fitted, and after a few days' run, an examination of the cylinder showed signs of the old trouble returning. The cylinder was carefully gone over with an oil stone, the cylinder oil supply increased and the wristpin box slackened off, when no further trouble developed after 3 yr. service.

RECEIVER.

Questions Answered and For Answer

Expert Help When In Trouble. If You Want Quick Answer Enclose a Stamp

Operator's Boiler Examination Questions

WHAT IS a bridge wall; where is it located, and what is its use?

A. A bridge wall, as ordinarily referred to in steam boiler work, is a masonry structure directly back of the furnace grates, extending across the entire width of the furnace and rising to a height somewhat above the level of the grates. Its objects are to give the proper direction of travel to the hot gases, causing them to rise towards the heating surface of the boiler; also to hold the fuel at the rear of the grates.

2. What would you do in case water dropped out of sight very suddenly, with hot fire under boiler?

A. If the water should suddenly drop out of sight and not return to its normal level, the only safe procedure would be to bank the fires at once with ashes or green coal, close the draft, cut the boiler off from the line and allow it to cool off.

3. What precaution would you take in keeping cold air out of your furnace?

A. Keep your fire doors closed as much as possible to keep the cold air out of your furnace, and when fire doors are opened, keep damper as nearly closed as possible without having hot gases escape from fire doors.

4. Is there any saving in using shaking grates?

A. If properly handled, a marked saving may result from the use of shaking grates, because of less opening of fire doors and less fuel lost through grates. Whether or not saving is realized depends entirely upon the care exercised by the operator.

5. What is a self-contained boiler?

A. A self-contained boiler is one having the fire box or furnace built integral with the boiler, such as locomotive or Scotch marine types.

6. Do you ever have to take up the wear in the valve gear of a duplex pump?

A. As wear occurs, it is necessary to take up on the valve gear of a duplex pump, but at proper speeds of running the wear is slow.

7. What is the water space in a boiler?

A. The interior of boilers is said to be made up of 2 parts, namely, the water space and the steam space. As its name implies, the water space is that space occupied by the water, extending in a tubular type to some 3 in. above the tubes.

8. Where does the side wall begin to close in on a boiler?

A. The side wall ordinarily closes in on a horizontal return tubular boiler at ½ to ⅔ of the height of the shell.

9. Would you blow out a boiler with pressure on it if letting down to wash out?

A. No. Allow pressure to fall to practically zero before blowing down entirely. It is, of course, permissible to open safety valve occasionally to reduce the pressure gradually. If, however, there is no particular hurry, the best method is to leave the boiler alone, allowing the pressure to reduce as it will; and in this way, let the shell cool off without being subject to any severe strains.

10. What defects would you look for when cleaning a boiler?

A. Scale, bags, corrosion and cracks.

11. What is a simple remedy to clean the tubes in an injector?

A. Immerse the injector for 24 hr. in a solution of 1 part muriatic acid to 6 parts water.

12. What precaution would you take to your blowoff?

A. See that the blowoff valve or valves are tight and that the entrance to the line and the line itself are free from all obstructions. Also, that blowoff line is protected from direct heat of gases.

13. What precaution would you take while blowing down a boiler with a good hot fire under it?

A. No boiler should be entirely blown down or emptied with a hot fire under it. If the blowing down is, however, only for the purpose of removing sludge or sediment, the blowoff valve should be opened for but a short time at frequent intervals. A good method to follow is to open the valve gradually until wide open and then at once slowly close it again. If there is a valve and a straightway cock, open the cock first, then the valve. Close in reverse order.

14. What causes a boiler to bag?

A. An accumulation of scale or oil over the fire will cause a boiler shell to overheat and bag at that point.

15. Give two reasons for a boiler being lower at back end.

A. A boiler is generally set so that the rear end is lower than the front end in order to allow all sediment and sludge to settle at the rear and thus render it more easily removed by the blowoff. Also the water can be completely drained when laying up the boiler.

16. Where is the blowoff pipe connected to boiler, and what kind of valve used?

A. The regular blowoff pipe should always be connected at the rear bottom end of the shell. It is best to use 2 valves on a blowoff line, one a globe and the other some form of quick-closing valve, a gate or cock.

17. What is mostly used to feed a boiler with?

A. Injector or pump.

18. While cleaning a boiler inside, what defects would you look for?

A. See answer to question 10.

19. While running a boiler, which blowoff would you use, the top or bottom?

A. Whether top or bottom blowoff should be used depends entirely upon condition of water. If this contains more matter which floats on the surface than will settle to the bottom of the shell, it will, of course, be necessary to use the surface blowoff more frequently. Should, however, there be little matter which will remain on the surface of the water but considerable which will deposit at the bottom of the shell, the bottom blowoff will be opened more frequently.

20. What makes grate bars warp? Give remedy.

A. Grate bars warp by coming in continuous contact with incandescent fuel bed. Water kept in the ash pit will cool the bars.

21. Why is it good practice to clean fires quickly?

A. Fires should be cleaned as quickly as possible to allow as little cold air as possible to enter furnace and come in contact with hot shell plates. Also to avoid dropping the steam pressure more than necessary.

22. What precaution would you take with fusible plug?

A. See that fusible plug is clean of all scale and soot, and that the filling does not show signs of crystallizing.

23. What precaution would you take to coke your coal before distributing on grate bars?

A. See Boiler Operation, page 55, Jan. 1, 1915, issue of Practical Engineer.

24. How would you handle a boiler if the safety valve stuck and the gage showed 25 lb. more than valve was set for?

A. Reduce pressure, and carry no higher pressure than gage is set for until the boiler can be shut down. When pressure is off and boiler cooled, remove safety valve and repair.

25. What is a butt strap joint?

A. A butt strap joint is made up by bringing the ends of the plate to be joined together and placing straps inside and outside the joint, riveting them so as to allow rivets to extend through both straps and the shell plate.

26. How would you handle a boiler that was foaming badly?

A. Do not allow water to rise above 2 gages; blow down frequently and do not force more than absolutely necessary.

27. How would you connect steam gage to boiler to keep steam from coming in contact with spring? Give in full.

A. Make a full-turn bend in the pipe connecting the gage to the boiler, and see that this bend is filled with water, thus preventing steam from coming in contact with interior parts of gage.

28. How would you connect safety valve to boiler?

A. Safety valves should be attached directly to a flanged nozzle connection riveted to the shell, with no piping or valve between boiler and safety valve, and no other connection to the nozzle.

29. How could you tell how much water you had in boiler with one gage of water in water glass?

A. Determine height of water above bottom of shell, in inches; calculate area of head in contact with water, in square inches. To do this, from total area of head, subtract the segment above the water line. Area of that segment is:

$$A = \frac{4\,H^2}{3}\sqrt{\frac{2\,R}{H} - 0.608}$$

A = area in sq. in.

H = height from water line to top of shell.

R = radius of shell.

Reduce to square feet and multiply by length of shell in feet; this gives you the volume of the shell up to the water level. From this must be taken the volume occupied by the tubes. Determining volume taken up by tubes, in cubic feet, by multiplying cross-section of one tube, in sq. in., by number of tubes, dividing by 144 and multiplying by length of tube in feet. Subtract this from volume of shell as determined. This gives cubic feet of water in the boiler.

30. How would you connect steam line to boiler to get superheated steam?

A. Saturated steam line from boiler is carried to superheater and header connected to superheater outlet.

31. What is a combustion chamber, where is it located, and what is its use?

A. The combustion chamber is ordinarily located directly back of the bridge wall and consists of that space bounded by the bridge wall, rear wall, floor and bottom of boiler shell. The purpose of the combustion chamber is to provide a space in which the hot gases may complete combustion.

32. What would you do when first going on watch?

A. Blow down the boiler one gage, if there is plenty of water. Try out water column, gage glasses and low and high water alarm, if such are used; test the safety valve and see that things in general are in proper operating condition, especially on feed water supply system.

33. How would you cut boiler into header with other boiler, carrying 100 lb. of steam?

A. Bring pressure on incoming boiler up to 105 lb., then open header valve slowly.

34. What would you do on taking charge of boiler plant?

A. Go over entire equipment to see that everything was in proper condition for safe and economical operation. If such is not the case, make necessary repairs and changes as soon as possible.

Freezing of Water Pipes

WHAT CAUSES a water pipe to burst? Is it the ice in the pipe, or is it the heat applied to thaw the ice?

2. Will a pipe freeze that has hot water in it sooner than one containing cold water? Assume both pipes to have like exposure. J. J. H.

ANSWERS

IT IS the freezing of the water which bursts the pipe, and not the thawing. When water freezes, it expands. If you think a moment, you will realize this, for a bottle of water left outdoors uncorked will have a plug of ice forced up through the neck as the water freezes.

In the case of a pipe, if it begins to freeze at a distance from the end, and then freezes toward the end, there is no place for the expansion to relieve itself, and it bursts the pipe. The thawing of water never does

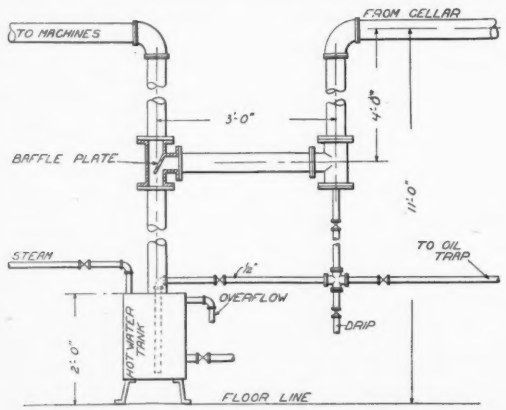
any harm to the pipe, unless the thawing be attempted with an open flame or with so strong an electric current as to overheat the metal, but this is most unlikely to happen.

2. In regard to the freezing of hot and cold water pipes, there is a peculiar action here which does take place, but is hard to explain. The writer has knowledge of 2 places where there are hot and cold water pipes side by side, with exactly the same exposure, and frequently, on an extra cold morning, the hot-water pipe will be stopped by a slight freezing, while the cold-water pipe will flow freely. Of course, this does not happen at any time when there is circulation of water through the pipes, that is, when water is being drawn, so that the hot water is kept flowing through the pipe; but when the water is not circulating, the hot water pipe is far enough from the boiler so that the heat is not transmitted to this exposed point.

The heating of the water tends, of course, to cause the settling out of any contained solids, leaving the water more nearly pure than that in the cold water pipes, and this may be the cause of the quicker freezing. Again, it may not. The question is a hard one, but the fact remains. A. L. R.

Trouble with Ammonia Regenerator

A SHORT TIME ago, we installed what was supposed to be an ammonia regenerator, which does not generate as the maker guaranteed it would. At any rate, I am not satisfied with it as a regenerator, and as my experience with them has not been very wide, I again come to Practical Engineer for advice and help. I am enclosing herewith a sketch which I believe will be of some help to you in solving my problem. It is installed directly in the suction line, 16 ft. from compressors, which are 2 Vilter horizontal 25- and 15-ton machines.



AMMONIA REGENERATOR PIPING CONNECTIONS

In the first place, you will notice the absence of valves in connection with it, and no arrangement to bypass to the machines. The gas is supposed to strike the baffle plate, and the oil and weak ammonia to drop to bottom and be regenerated by the hot water; then the oil and dead ammonia can be let off to sewer. A ½-in. pipe inside of regenerator leads to the oil trap. This ½-in. pipe goes down inside of regenerator close to bottom. Now we are supposed to let weak ammonia around from oil trap to regenerator and regenerate it; but instead of its remaining there until regenerated, the compressors seem to take it at once and return it to oil trap, where taken from. Now I cannot see any sense in circulating from one place to the other, without any good results, so have decided to let it stand until I find out something about it. Of course I have my own ideas about it, and have told them to my employer, but would like to hear from you, as you would be likely to have more experience on these things than I. J. J.

A. It is rather hard to say, at long range, whether your trouble is due to the regenerator or to your method of handling it. I take your sketch to be diagrammatic. A single baffle plate where the returning gas enters the top of the apparatus would scarcely be ample to separate out much oil, especially so unless the gas velocity is quite slow at this point. The oils used in refrigerating machines are so light that it is difficult to separate them from the ammonia, especially at medium and high temperatures.

Increase the difference in weight between the oil and the gas as much as possible by frosting back nearly to the regenerator. The colder, more sticky oil will be less likely to pass on to the compressor than warmer, more fluid oil. The baffles should be so constructed as to offer a number of reversing surfaces so that if the oil is not all separated out when it comes in contact with the first surface, more of it will be when it strikes the second, third, etc. The areas around the baffles should be large so that the velocity of the gas being slow, will not sweep the oil from the plates and again entrain it as it passes to the compressor. Possibly the valve in the line leading from the oil trap has been opened too wide.

If, as I assume, the oil trap referred to is the high-pressure trap, there will be the difference between the head and the back pressure, tending to push the oil from the trap through the regenerator. Unless the valve is only just "cracked" and the hot water jacket kept in active operation, the high-pressure gas will blow the oil which it carries, and that in the bottom of the regenerator, so vigorously that it might readily return to the compressor as described.

There is no such thing as weak ammonia to be regenerated. Ammonia is ammonia, consisting of one part by weight of nitrogen in chemical combination with 3 parts of hydrogen. Nothing can happen to ammonia to change its characteristics other than dissociation or separating of the 2 gases, in which case there will be 2 gases mechanically mixed, rather than chemically combined to form ammonia; when, and if dissociation takes place, the foul gases are purged out at the condensers. They can not be "regenerated." The function of a so-called regenerator is to separate out the oil that works out through the expansion coils and back with the ammonia gas. F. E. MATTHEWS.

Correction Note

On page 229 of the Feb. 15 issue, in the letter from R. G. P., a word was unfortunately omitted by the typesetter which changes entirely the meaning he intended. At the close of his letter as printed it states "Open B and A." This should read, "Open B and close A."

Problems For Discussion By Readers

What Would You Do If You Had These Conditions To Meet?

Cleaning Injector Tubes

IN REPLY to the question asked in the Feb. 15 issue on this subject, several replies have been received, most of them giving approximately the same method. We are, therefore, abstracting the letters to give the essential points and differences:

J. O. Benefiel writes: "To clean lime out of the injector, take equal parts muriatic acid and water, soak the injector in it, or if it is too big to dip, plug some of the holes with waste and pour in muriatic acid solution until it stops boiling; then wash out with water. The same solution may be used to clean gage glasses. Put the solution on a bunch of waste and rub the glass with it. I also cleaned the jackets of a 150-hp. gas engine by plugging all outlets, except those on top, and pouring in muriatic acid. This was kept up for about 6 hr., and we got a thorough job. It took $5 worth of acid, but was cheap at that. I believe the acid is about 25 cents a gallon in our case, but we buy it in carload lots."

E. H. Lewis writes, "Immerse the injector in a solution one part muriatic acid to 8 parts water, and leave in the solution over night, or 24 hr. if possible."

J. C. Hawkins writes, "Where soda ash or other boiler compounds are used, these may be pumped through the injector and will cut the scale from the tubes. Another good method is to remove the tubes and soak them for several hours in a solution one part muriatic or hydrochloric acid to 10 parts water. After the tubes have been in the solution for a time, fish out with a stick or wire and wash off the acid. Be careful not to get this acid on the hands or clothes. If the scale is softened, scrape it out with a sharpened stick and polish the tubes to get them free from scale. If the scale does not come off easily, leave the tubes in the solution for a longer time."

P. E. Merriam writes, "Immerse the injector in a solution one pint of muriatic acid to 1½ gal. of water. Leave in the solution until the scale is loosened and the internal parts can be easily removed. When removing and replacing these, and also in removing and replacing the injector on the pipe lines, be careful to use a wrench which fits the nuts accurately, so that the unions may not be injured. Special care must be taken not to jam or scratch the tubes or to alter their shape or area in any way.

"In smaller sizes, a screw driver is used in the end of the tube to remove it; in the larger sizes, a socket wrench. In both cases, care should be taken that the screw driver or wrench is not allowed to slip and round the corners of the slot or the nut.

"Application of graphite to the threads will permit easier taking apart next time. In one case which the writer observed, an automatic injector was cleaned thoroughly, and operation afterwards was worse than before cleaning. After it had been used a while, the operation improved for several months, until it again became necessary to clean the tubes. The reason for this was, that wear of the tubes had increased their diameter so that when scale was cleaned, the worn parts did not have the same relation to one another as in the original design, but after some scale had formed, the relations became more like those when the injector was new."

Cleaning Gage Glasses

AS TO the proper method of cleaning gage glasses, I would suggest not cleaning them at all. When they become so coated as to call for cleaning, it is better and cheaper, if time is of any value, to put in new ones.

Most engineers must have noticed how thin the tip of a boiler gage glass becomes by the many grooves on the inside. That which appears to be dirt is generally found to be these many fine grooves, and when the glass is in this condition, the tip end will be found in such shape as to render the glass of little further value. The packing also is pretty well gone and almost everyone knows what it means to try to take up on an old gage glass when it once starts to leak.

I would not recommend the use of acid for cleaning these glasses, as its effect on the boiler, glass, packing and fittings should be considered.

Lubricator glasses may sometimes be wiped out by means of a piece of cloth attached to the end of a stick; but when one considers that these glasses are nothing more than short pieces of scrap of little value, it readily follows that the use of a new piece will be of greater advantage.

HARRY D. EVERETT.

I NOTICE that I. O. S., in answering F. H. J. and J. H. H., advises the use of hydrochloric acid. This acid, while a fairly good chemical solvent, has an erratic action when used to clean stains on gage glasses. A chemical that has better solvent properties, does not injure the hands or boiler, can be easily obtained, and is used in the same way as hydrochloric acid, is carbon tetrachloride. This can be handled with impunity. It will not burn; in fact, it is used in many well-known electrical fire extinguishers. The dry cleaners in the tailor shops use it. It is not expensive and does the work where other methods fail. You can use it with a swab if so desired.

H. E. WEIGHTMAN.

AT CUENCA, Ecuador, an electric light plant is under construction, the machinery being furnished by General Electric Co. A municipal plant is to be erected at Daule, and a water and light plant at Tulcan.

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Measurements and Calculations

Mental habit is one of the hardest things in the world to alter—especially if it is in the other fellow. We grow to let the mind work automatically as in addition and multiplication, and a change involves concentration and effort which are not only a burden, but involve liability to error. And so in measurement and computation we struggle with a complication of systems, rather than make the big effort needed for a real solution of the problem.

Man learned to count and compute on his fingers, and still learns that way. Hence, his computing is by 10s or the decimal system, and 10 digits are universally used in this work. But in measuring the natural division is by halves, thirds and quarters; division into tenths and fifths is bothersome and inaccurate, hence 12, which is divisible by 2, 3 and 4 is the natural number of divisions for measurement.

To get complete reconciliation of the systems of measurement and computation now used by English-speaking peoples will involve radical departure from some present standard. The metric system, devised by scientists largely interested in computation, brought the system of measurement into harmony with the natural method of computing, but at a loss in convenience of measurement, for only 2 and 5 are available as even divisions of the unit, and one-fifth is not a natural or convenient division for ordinary work, however well it may apply in scientific measuring instruments.

The opposite method of compromise, i.e., using 12 digits, has been proposed and many details worked out. It presents no insurmountable difficulties except ingrained human experience and custom, and the fact that our fingers still remain 10, and these are the first helps to counting and calculating that the child uses. The monetary systems of most countries are also decimal, so that the disturbance to commerce would be unthinkable if a duodecimal or 12-digit system of reckoning were attempted.

Length of the yard was originally derived from the human reach, and then standardized as a metal bar in London. Length of a meter was meant to be a division of a quadrant of the earth's surface, but the attempt failed, and it is now a metal bar in Paris. So that the meter and yard are both purely arbitrary lengths, and the same applies to the pound and the kilogram. It would seem that a logical thing would be to establish a new unit of length that will harmonize both systems and permit of subdivision and calculation in its own decimal units, and easy conversion to either system. This might well be established as the American system, and adopted by the Pan-American Union as an allowable standard, the names of units being chosen by a scientific committee named by that Union.

For the standard of length of such a system 5 ft. or 60 in. seems to offer many advantages. It is equal to 1.524 meters; to 152.4 centimeters. This conversion factor is divisible by 2, 3 and 4, and the length in inches, 60 is divisible by 2, 3, 4, 5 and 10. Consider a few of the relations of the New Unit, or nu. for short:

½ nu. = 30 in. = 2.5 ft. = 76.2 c.m. = 0.762 m.
⅓ nu. = 20 in. = 1⅔ ft. = 50.8 c.m. = 0.508 m.
¼ nu. = 15 in. = 1¼ ft. = 38.1 c.m. = 0.381 m.

While the multipliers for conversion to metric measurements look irregular, they are exact in 3 places and are immeasurably simpler than conversion from yards or feet or inches to metric units.

Going to larger measurements, the mile is 1056 nu. If a greater unit or gu. be taken, as 1000 nu., or 5000 ft., it will equal 1524 meters or 1.524 km., so that the same conversion multipliers will hold between the gu. and the kilometer as between the nu. and the meter.

For areas the square new unit equals 2.322 square meters or 25 sq. ft., and for volumes the cubic new unit equals 3.54 cubic meters or 125 cu. ft. And to correspond to the gallon, a cube of 0.1 the new unit on a side or 6 in. might be used, giving a volume of 216 cu. in. or ⅛ cu. ft. or 3540 cu. centimeters.

If we wish to divide the new unit decimally, 0.1 nu. = 6 in., 0.5 ft., or 15.24 c.m.; 0.01 nu. = 0.6 in., 0.05 ft., or 1.524 c.m. and 0.001 nu. = 0.06 in or 1.524 m.m., all of which maintain the same relative simple relations as the new unit, the foot, the inch and the meter.

If the United States of America is to enter world markets, our measurements must conform to those of the countries with which we trade, and a simple relation of units, or adoption of the metric units for foreign trade must come.

In one measurement with which engineers have frequently to deal, there seems no logical course but to change over entirely, namely the measurement of temperatures. All thermometers are graduated on the decimal scale, and there is no possible defense of the Fahrenheit scale except that it exists. The Centigrade scale has science, good sense and large use in its favor, and the sooner the cumbersome Fahrenheit scale disappears the better. We shall need new steam and other tables, but that is comparatively easy, and the use of freezing as 0 deg. and boiling as 100 deg. has everything in its favor. That miserable 32 which appears in nearly every steam computation is a nuisance. If the weather department will only urge and Congress will sanction the use of the Centigrade scale in all weather reports, the change would be completed in a few months' time and we should forget the old scale much to the benefit of everybody.

News Notes

ANNOUNCEMENT is made of the death of George R. Ray, President of the Manistee Iron Works Co., at Manistee, Michigan, on Monday, Jan. 3, 1916. Mr. Ray was a pioneer and prominently identified in the development of equipment, particularly the vacuum pan, for the manufacture of salt.

ON MARCH 18, the Annual Stag of the New England Association of Commercial Engineers will be held at the Revere House, Boston, Mass., reception at 6:30 and dinner at 7:15 sharp.

The committee in charge is, Fred M. Couch, Harry M. Colby, Fred B. Lythgoe and Geo. W. Denyven. Tickets can be secured from the committee or from the office of the Association, 53 Devonshire St., Boston, $1.50 per plate.

PROPOSALS WILL be received until Mar. 23 at the office of the Supervising Architect, Treasury Dept., Washington, D. C., for all mechanical equipment except elevators for the U. S. customhouse and courthouse at Wilmington, N. C. Drawings and specifications may be obtained from the custodian at Wilmington, N. C., or from the Architect at Washington, D. C.

AS AN EXPLANATION and index of the better business conditions now prevailing in the United States, the figures for imports and exports for December, 1914, and 1915, and the totals for the 2 years, are interesting. As given by the Department of Commerce, these are: Imports for December, 1914, $114,656,545; for December, 1915, $171,832,505. Exports for December, 1914, $245,632,558; for December, 1915, $359,306,492. For the entire years: Imports, 1914, $1,789,276,001; for 1915, $1,778,596,695. Exports, 1914, $2,113,624,050; for 1915, $3,547,480,372. Thus while imports decreased slightly for 1915 as against 1914, exports increased about $1,434,000,000, and during December, 1915, imports increased over $57,000,000 and exports increased over $113,670,000, showing a rapid gain in trade both ways toward the end of 1915.

THE SOCIAL COMMITTEE of the Rhode Island No. 2 N. A. S. E. issued invitations to its members to attend a Ladies' Night Entertainment on Saturday evening, March 11. Some of those who took part on the program were Jack Armour, Frank Martin, Billy Murray, Bert Self, and other well-known New York entertainers.

DR. HENRY K. BENSON, professor of industrial chemistry at the University of Washington, in Seattle, has been appointed director of the newly-established Bureau of Industrial Research, the first such institution on the Pacific Coast.

One fellowship dealing with a problem of the iron and steel industry and amounting to $2000 has already been established as a result of the co-operative spirit existing between the Bureau and the business men of the Pacific Northwest. Other fellowships are contemplated.

The Bureau will attempt to co-ordinate the research activities already undertaken by the university, with a view to the utilization of the resources of Washington.

BULLETIN RECEIVED from Thomas E. Durban, Chairman of the Executive Committee of the Uniform Boiler Law Society, calls attention to a point not generally understood, that an affidavit covering the proper use of the A. S. M. E. boiler stamp must accompany every application to the Society for such a stamp. The stamp will be furnished by the American Society of Mechanical Engineers only upon receipt of application accompanied by an affidavit that this stamp will be used only on boilers built in accordance with the A. S. M. E. Code. The right to use this stamp will be forfeited if the stamp is placed on any boiler not conforming to the requirements of the Code.

The secretary sends also a list of valve manufacturers who have written that they are prepared to furnish valves built to the requirements of the A. S. M. E. Code, but in ordering valves for these conditions, it must be specified that they are to fulfill A. S. M. E. requirements. The list of manufacturers is: American Steam Gauge & Valve Mfg. Co., Ashton Valve Co., and Crosby Steam Gauge and Valve Co., all of Boston, Mass; Consolidated Safety Valve Co., of New York; Crane Co., of Chicago, and Lunkenheimer Co., of Cincinnati.

Power Apparatus in Shop and Market

New Ideas In Making, Buying and Selling

Lyons Atlas Air Compressor

THIS compact outfit made to meet the widespread demand for a simple, reliable, efficient and inexpensive compressor unit, is built by the Lyons Atlas Co., of Indianapolis, Ind., in 3 sizes, with capacities ranging from 35 to 150 cu. ft. of free air per minute and for pressures up to 200 lb per sq. in. It consists of a 4-cycle, single-acting, vertical gas engine combined in a single unit with a 2-stage, direct-driven air compressor, the power cylinder and its accompanying air cylinder being a continuous casting, requiring only a single differential piston, one connecting rod and one crank.

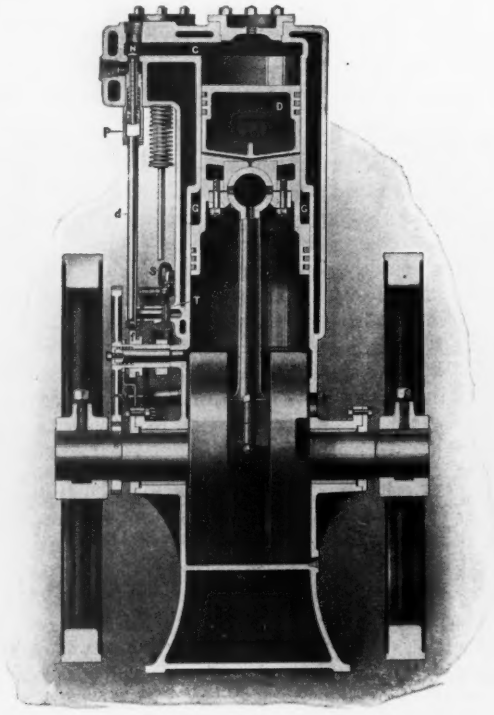


FIG. 1. CROSS SECTION OF LYONS ATLAS COMPRESSOR

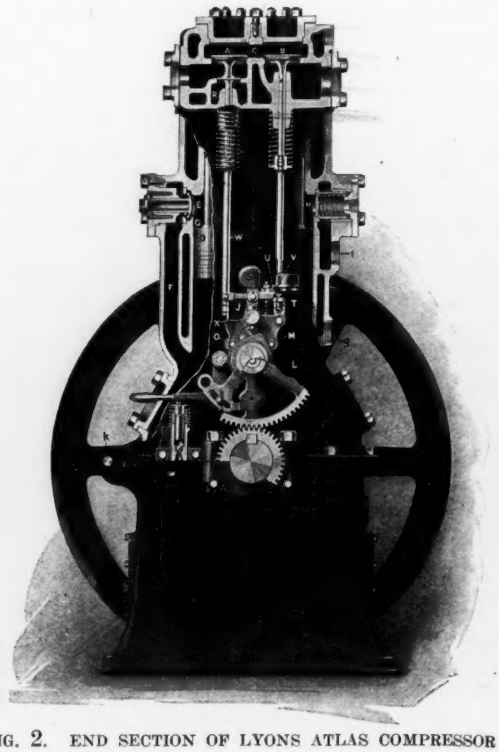


FIG. 2. END SECTION OF LYONS ATLAS COMPRESSOR

The engine operates on the usual 4-stroke cycle. The speed is regulated by an inertia weight pivoted to the bell crank, which carries the exhaust roller. As the speed increases above normal, this weight hangs back, stretching a spring which, through connecting parts, holds the suction valve closed and the exhaust valve open. As soon as the speed falls to normal, the spring relaxes and the regular cycle is resumed. Two heavy flywheels, together with the crank disks, which practically fill the crank case and reduce the clearance, furnish the necessary inertia to enable the hit and miss governing device to maintain a sufficiently constant speed, notwithstanding that there are 2 air compressing strokes to one working stroke of the engine.

The final air pressure is reached through 2 stages of compression. When the air piston is at the top of its stroke, the crank case is full of air at atmospheric pressure, admitted through port K, shown in Fig. 1, which registers with a port in the nearest crank disk. On the downward stroke this air is compressed in the crank case; then, referring to Fig. 2, it flows through passage F and valve E into the annular chamber G, and raises the absolute pressure therein to approximately 20 lb. Valve E closes as the piston starts on the upward stroke, and as soon as the pressure in the annular space G reaches the receiver pressure, discharge valve H opens, allowing the air to pass into the receiver during the remainder of the upward stroke. Since the pressure in the crank case assists the piston on the upward stroke, and the location of the port in the crank disk is such as not to open port K until atmospheric pressure is reached, no work is lost and high efficiency is secured.

While the power end is regularly designed for the use of gasoline, it can be arranged to operate on kerosene or gas, natural, illuminating or producer.

In order to realize the greatest economy, the water circulating around an air compressor cylinder should be as cold as possible, while the water in the jacket of a gas engine should be just the opposite. This ideal condition is approached by using the same water to prevent excessive heating of the power cylinder that has previously cooled the contents of the air cylinder. It is first taken through opening g, Fig. 2, at the bottom of the air cylinder jacket, whence it passes upward and entirely around the air cylinder; absorbing the heat of compression so that before it reaches the power cylinder jacket its temperature has increased sufficiently to maintain a high thermal efficiency throughout the combined cycle.

Slide Rule and Flow Computer

THIS new rule can be used for all ordinary computations of multiplication, division, square root, etc., and in addition offers not only a direct solution of all problems involving the flow of liquids, but may be used to determine the size of pipe necessary for all different conditions. The instrument is of such size as can be carried by the user in the pocket.

The special features of this slide rule are the result of experimental work combined with a careful study of the subject of the flow of fluids in pipes. The ordinary methods that have been used in solving such problems have required the determination of special formulas for each particular case. Even after the formulas were determined much time and tedious work were still required when the occasion for using the formulas presented itself, notwithstanding the many steps advanced to facilitate their solving. With the introduction of this computer all the tedious work connected with the various problems is eliminated.

This slide rule will, therefore, prove of great benefit not only to all members of the engineering profession, but as well to all practical mechanics dealing with the installation of various piping systems.

Each quantity involved in the figuring of problems dealing with "Flow of Liquids Through Pipes" is assigned to a separate scale as indicated on the face of the rule. The required answers are read direct from the scales and the probability of making an error with the use of the instrument is slight.

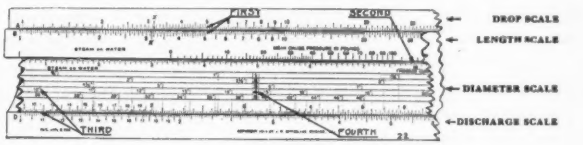


FIG. 2. METHOD OF USING SLIDE RULE

The rule is made of solid celluloid and is permanently attached to a leather case. Directions for the operation are printed on the inside of the cover, so as to eliminate any chance of error, by the directions of use being forgotten. The rule has 2 slides, also made of solid celluloid, accurately fitted to work in separate grooves. The slides are reversible, one side being used for steam or water flow problems; the other, printed in a different color, being used for problems dealing with gas or air.

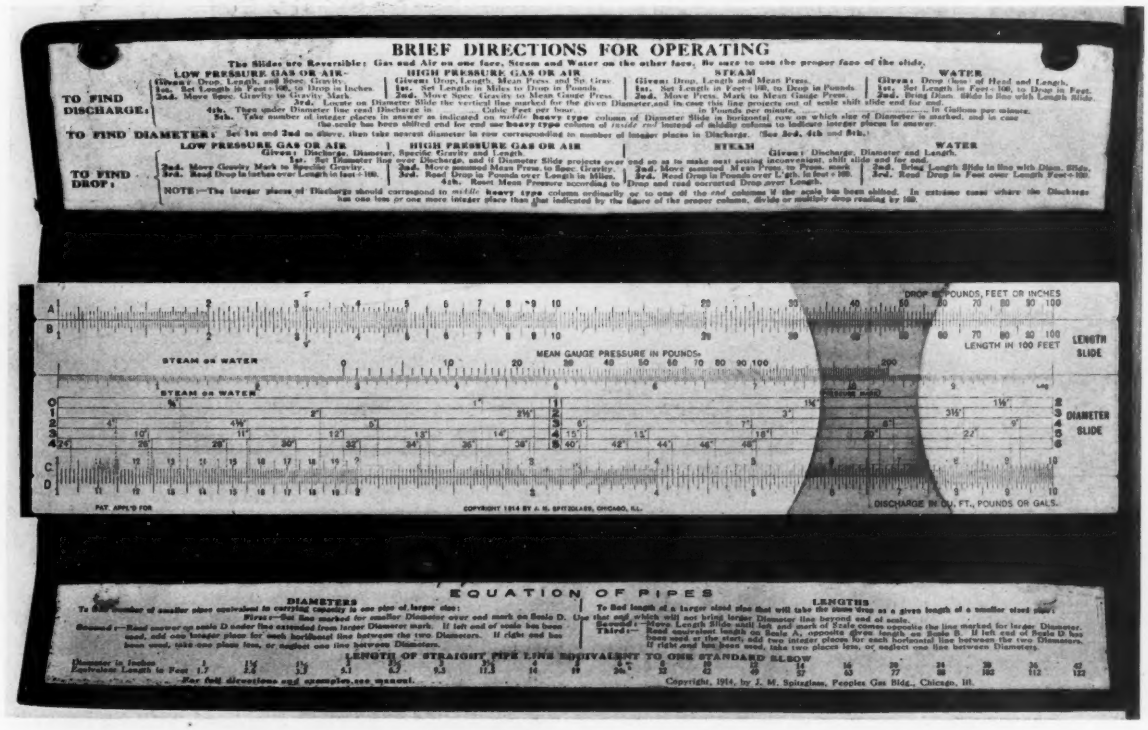


FIG. 1. NEW SLIDE RULE DESIGNED PARTICULARLY FOR COMPUTING PIPING PROBLEMS

In order to demonstrate the simplicity of use the following problem is given: see cut, Fig. 2.

To find the size of pipe necessary to deliver 1088 lb. of steam per min. (2176 hp.) through 510 ft. of pipe.

Initial pressure 127½ lb. Drop through pipe 5 lb., mean pressure (initial minus ½ drop), 125 lb.

First. Set 5.10 (510 ft.) on length scale to 5 (pounds) on drop scale.

Second. Move diameter slide until pressure mark coincides with 125 lb. mean gage pressure.

Third. Set slide on discharge scale at 1088 and the answer is a 10-in. pipe.

In the middle heavy type column on diameter slide the figure 4 in the horizontal row where diameter is marked, is seen. This corresponds with the 4 integer places in the number 1088. If there had been 5 integer places, making the problem require 10,888 lb. per min., under the same initial and final pressure, then the diameter would have been in the horizontal row marked 5. This shows a 26-in. pipe the required size.

A book of problems goes with the rule and after a perusal of this is made, it is seen that whether the problem is for steam, gas or fluid, the solution is but a repetition of the above. The order can be reversed for any combination.

Sales right of this rule is being handled by Gordon M. Proudfoot, Chicago, Ill.

Portable Air Supply Outfit

FOR those who have the care of a fleet of automobiles, an economical portable air supply outfit, which is shown in the illustration, is manufactured by the Leader Iron Works, of Decatur, Ill. The complete outfit consists of a motor, air compressor, automatic controller, air tank, and fixtures.

LEADER AIR SUPPLY OUTFIT

The motor is a Westinghouse 1-hp. repulsion induction type, having a high starting torque and low starting current. Frequent starting and stopping of the motor is eliminated by the use of a 14 by 36-in. welded air tank which is of sufficient capacity to inflate several tires. The air pressure in the tank is maintained at a value between 110 and 150 lb. by an automatic controller on the motor. Thus air at the desired pressure is always available.

The compressor has a 2½ by 3-in. cylinder which is air cooled and provided with a hand unloader. Fittings for connection are furnished as well as a 5-in. pressure gage, pop valve, drain cock and other convenient accessories.

New Adjustable Sprocket Rim

THE Babbitt Steam Specialty Co., of New Bedford, Mass., has placed on the market its new adjustable sprocket rim, which does away with the inconvenience, time required and expense incurred, of operating valves in inaccessible places. These rims are made adjustable to the wheel of any valve, so that a dealer can carry in stock an assortment to cover almost any requirements without delay. To adjust this rim on the wheel means simply the setting up of 3 nuts, and expense is very small.

BABBITT ADJUSTABLE SPROCKET RIM

With this sprocket rim attached, the valve is conveniently operated by means of a chain as shown, no matter in what position the valve may be.

To attach, adjust the hook belts to the rim of the wheel, having the bolts pass through the slots in the lugs; center the sprocket rim on the wheel and tighten the nuts.

Recording Steam Engine Indicator

COMBINING THE INDICATOR AND THE PLANIMETER A CONTINUOUS CARD RECORD AS WELL AS RECORD OF POWER IS GIVEN. BY STERLING H. BUNNELL

TO measure the power developed by a steam engine under variable load is one of the most difficult problems that is presented to engineers. Transmission dynamometers have been used in some cases, taking the form of shaft couplings with spring connections, with a device for showing the deflection of "twist" of the coupling under the load; or idler pulleys running on the main belt, measuring the tensions of tight and slack sides. All of the transmission dynamometers are inaccurate in service and subject to vibration so severe that the indication of the dial or balance is uncertain.

At the other end of the engine, the steam cylinder, there is already an instrument available for accurately measuring the work done by the steam on the piston, namely, the indicator. The limitation of the indicator is in the fact that it can generally take only 2 diagrams on a single piece of paper. With an engine under varying load, the only way of measuring the work with the indicator is by taking random diagrams at as frequent intervals as possible, and averaging the areas of the diagrams, trusting to chance that they represent a fair mean of the load variations. The task of running off areas of diagrams with a planimeter is in itself no small one when many diagrams are to be

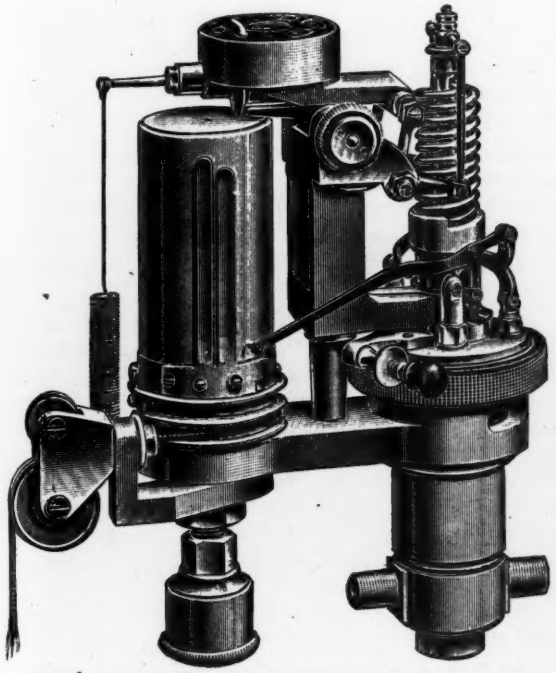


FIG. 1. BOTTCHER INDICATOR WITH SINGLE DRUM

measured. The operations of taking the diagrams and measuring their areas can now be performed by a single instrument, the Bottcher recording indicator, which seems to be adapted to fill a long felt want in power measuring appliances.

The Bottcher instrument combines an indicator of usual form with a planimeter actuated by the indicator piston. In running over an indicator diagram with a planimeter in the usual way familiar to engineers, it is evident that the operator's hand moves the tracing point of the planimeter over the same path previously traveled by the indicator pencil. If the pencil arm carried the planimeter point, the indicator would measure its own diagram. This is substantially the method of action of the recording indicator. The planimeter frame is carried on a swinging arm moved by the indicator piston, and the measuring wheel runs on the head of the paper drum. The combination of the 2 movements of piston and drum causes the wheel to trace a path proportional to the diagram made by the indicator pencil on the drum. It remains only to provide a counter to record the revolutions of the wheel to enable the instrument to measure and add the areas of the indicator diagrams from successive strokes at the end of the cylinder to which the indicator is connected.

The Bottcher recording indicator, as shown by Fig. 1, has the familiar form of the common indicator, but with some additions. The pencil and drum movements are as usual, and the piston rod is extended upward to carry an exterior spring. At the upper end of the piston rod a crosshead f,—Fig. 2—is connected by light links to bell-cranks h, carried by a bracket c. The motion of the piston rod is therefore transmitted to the planimeter frame, causing the latter to move to and fro across the head of the drum r. In operation, the planimeter frame is held down by the spring q, hooked over the pin p, thus keeping the measuring wheel in contact with the drum head. The wheel connects with a train of gears contained in the meter case l, where the travel of the wheel is indicated by the dials m, n, o.

In operation, the instrument is connected in the usual way to a pipe leading from an end of the engine cylinder, and to a reducing motion actuated by the engine

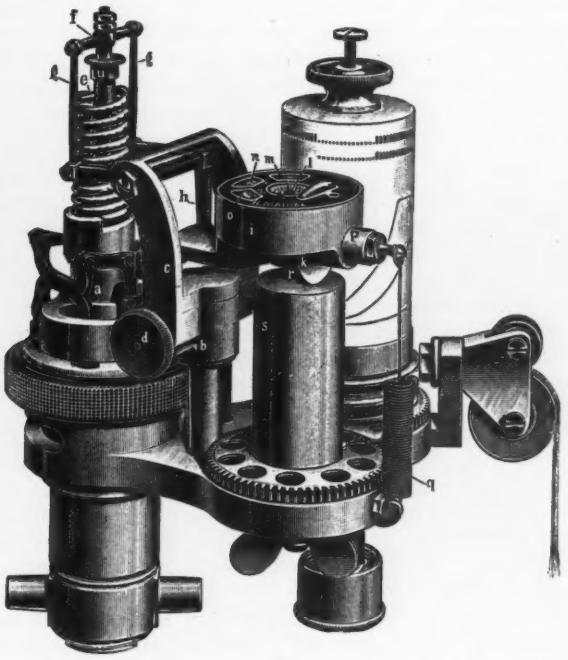


FIG. 2. FORM OF BOTTCHER INDICATOR WITH 2 DRUMS

crosshead. Upon opening the indicator cock, the planimeter frame and drum by their respective motions cause the measuring wheel to record on the meter dials a number which, when multiplied by the constant furnished by the maker for each instrument, gives the total area of all the diagrams traced by the indicator pencil. While the recorder is in operation, diagrams of the usual form may be taken by the pencil on a sheet of paper previously put on the indicator drum. Check diagrams taken in this way may be measured and compared with the planimeter reading.

With the recording indicator shown by Fig. 1, the paper can not be changed without stopping the recording. The 2-drum form shown by Fig. 2 overcomes this difficulty. This design provides 2 drums. One carries

the usual paper clips and is provided with a detent, so that the sheets can be changed at will. The other supports the planimeter wheel and is exclusively for the recording purpose. With this instrument a continuous record of the indicated horsepower of an engine can be made, while check diagrams can be taken at any desired intervals.

The Bottcher recording indicator is available for all steam and gas engines, compressors and pumps. It should have a wide application in the investigation of the power requirements of engine driven apparatus of every kind.

The manufacturer is H. Maihak, Germany, and the American representative, H. Bacharach, of Pittsburgh.

Books and Catalogs

BRIDGE FOUNDATIONS, by Wm. Burnside, 148 pages, 31 diagrams, London, England, price $1.10.

This book takes up the design and construction of foundations for bridges of all types, describing the foundation bed, abutment foundations, pier foundations and such accessories as coffer dams, stranded caissons, open caissons and pneumatic caissons. The book will be of aid to those who have bridge work to do, as the subjects are treated in a practical way and as concisely as possible.

OXY-ACETYLENE WELDING and Cutting; Electric and Thermit Welding, by Harold P. Manly, 215 pages, illustrated; Chicago. Price: cloth $1.00, leather $1.50.

In this work the author starts with a chapter on metals and their alloys, in which he discusses annealing, tempering, hardening, heat treatment and the restoration of steel. This is preparatory to the principal text of the book which gives in a clear and concise manner in following chapters the various methods of welding and cutting materials by means of oxy-acetylene blow pipe. It also describes the present commercial methods of securing oxygen and acetylene, from what companies they may be purchased, how they are shipped, also the care and precautions which must be taken in handling the gases used in this process. The work includes the application of the rules laid down by the insurance underwriters which govern this class of work, as well as instructions for the proper care and handling of the generators, torches and materials found in the shop. Special attention has been given to directions for handling the different metals and alloys which must be handled.

Facts which expert welders and metal workers find most necessary to have available have been secured and prepared especially for this book, and those of most general use have been combined with the chapter on welding practice to which they apply. Not only is the oxy-acetylene welding fully discussed, but chapters are given on electric welding, hand forging and welding and soldering, brazing and thermit welding.

The book is a practical treatise throughout and would be of value to anyone having metal repair work to perform.

LINK-BELT CO. HAS recently published a reprint of an article by Henry J. Edsall, which appeared in a recent issue of Coal Age, entitled "Insuring the Coal Supply." The article is of particular interest to industrial establishments at this time, owing to an impending strike of the coal miners. The book will be sent upon request to anyone who writes to the company for it.

WAGON AND TRUCK loaders, manufactured by Link-Belt Co., are described in a bulletin recently issued. These loaders are of the bucket type, mounted upon wheels, making them portable, and are of particular value where coal is to be loaded from ground storage onto trucks or wagons. The loaders are driven either by electric motor or gasoline engines.

AMERICAN FLEXIBLE METAL hose is made in a number of different styles for various purposes, including asbestos-packed, interlocked joints, asbestos packed with braided wire jacket, double groove rubber-packed, and single groove rubber-packed. The different styles, sizes and prices per foot are given in a convenient pocket folder issued by the American Metal Hose Co., Waterbury, Conn.

TRAMRAIL SYSTEMS, trolleys and electric hoists are described in catalog D which has recently been published by the Brown Hoisting Machinery Co. The catalog is well illustrated to show the various uses and advantages of Brown hoisting machinery for handling such materials as coal, ashes, etc.

A PAPER OF INTEREST to electric railway engineers and others interested in electrolysis problems is Technologic Paper 63 of the Bureau of Standards, Department of Commerce, Washington, D. C., which gives the results of a study of problems connected with leakage of current from electric railways. It is somewhat mathematical, both in the development of the theory and the working out of results, but the conclusions are put in practical form, and show how the escape of electricity from the rails is affected by increasing the track conductivity, such as careful bonding of joints, by using high resistance roadbed, and by shortening the distance over which a station supplies power.

IN A FOLDER recently received, the Francke Co., New Brunswick, N. J., describes in detail the Francke flexible couplings, showing how the pins of flexible flat steel springs are used to join the flanges, and the method by which these operate to give relief from lack of alinement and freedom from noise and vibration.

JONES PACKING CO., 30 Church St., New York, describes in a new catalog the various types of packings made by this company, including high-pressure ring and spiral packing, Jones stitched spiral and low-pressure spiral packings, as well as the diagonal ring, diagonal cord, and ammonia and hydraulic packings of various types.

IN FURTHERANCE of the plans for a month's campaign for house wiring, the Society for Electrical Development, 29 West 39th St., New York City, is sending out a booklet entitled successful House Wiring Plans, which gives in detail methods used by various companies and contractors for increasing the number of homes which enjoy the comforts, convenience and economy of electrical service. The booklet is full of interesting, practical information in regard to this line of effort, but is not a manual on the details of doing the work.

THE BARREL BOOK is the title given to a handbook on barrels, which takes up the question of the most suitable container for oil, based on experience of leading coopers and inquiries among oil shippers. This is written specially for the non-technical reader, and covers the preparation and use of barrels, handling and repairing, and a list of 8 largely used types of barrels, giving specifications and proper uses for each type.

Copy of the book may be obtained by a request to J. E. Watterson, 1420 Illuminating Bldg., Cleveland, O., mentioning Practical Engineer when writing.

"KEWANEE" specialties manufactured by National Tube Co., are described in a booklet entitled The Whole "Kewanee" Family. This book consists of 72 pages, printed in 3 colors, giving a complete list of the "Kewanee" specialties, instances of satisfactory use of the "Kewanee" union and specialties, and memo showing various types of literature issued by National Tube Company, descriptive of its different products.

The "Kewanee" union, the father of the "Kewanee" family, is known throughout the world, and the various other members of the family, while possibly not having such general use, are each equally useful in their particular spheres.

BULLETINS 154 and 110 have just been issued by the A. S. Cameron Steam Pump Works, 11 Broadway, New York City.

Catalog 154 is devoted to Cameron centrifugal pumps, sectional views are used to illustrate both the single and double suction open impeller types, and the booklet gives tables of capacities, speeds and horsepowers.

Catalog 110 covers the Cameron line of duplex pumps, including both piston and plunger types, with single and compound steam cylinders for general service, boiler feeding, tank service, water works, hydraulic elevators, automatic pumps and receivers, brewery, quarry and mining work. The catalog is well illustrated and also contains tables of sizes and capacities.

Copies of these bulletins are free on request to any of the branch offices.

WATCH THE WAY the Wind Blows is the title of a 3-color pamphlet just issued by the Westinghouse Electric & Manufacturing Co. It tells of the big breeze that the national advertising of Westinghouse fans is going to make this summer, and invites all dealers to secure the benefits of this breeze by directing it into their stores. "The Trade Wind that Blows All Summer" is the title given to the national campaign, while under appropriate headings the co-operative advertising and selling literature for local use is grouped. "Put the Breeze into Your Business" is the head of the page describing the benefits of local newspaper advertising. "Giving a Business More Air" describes the folder that will induce possible houses to install fans. "Put the Wind in Your Windows," "The Way to Win Women," etc., are some of the subjects treated. The book is well printed and comprehensive in the number and quantity of selling helps offered.

SOME LETTERS about Emerson steam pumps, also a list of names of users, are contained in a booklet from The Emerson Pump & Valve Co., Inc., Alexandria, Va.

FROM CROUSE-HINDS CO., Syracuse, N. Y., has just been received Bulletin No. 1C, entitled Narrow Panels. In it are illustrated the various types of panels built by this company and revised listings of types O and P panels.

PUTTING FACTS Behind Your Choice of Coal is the title of a booklet just received from the Fuel Engineering Co., New York. In this booklet the company gives a common-sense talk to business men, illustrating the need of a more thorough and scientific study of the choice of coals.

FROM THE LINK-BELT CO., of Chicago, has just been received Book No. 213, which is devoted to descriptions of machinery for handling, preparing and storing of sand, gravel, stone, etc. This book is complete in that it shows the entire equipment manufactured by this company for these purposes and will be sent upon request to anyone interested in this line.

ALLIS-CHALMERS MFG. CO. has just issued a new catalog describing its centrifugal pumps and centrifugal pumping units. These pumps are made both single and double suction, also single and multi-stage for direct connection to motors or turbines, or for belt drive. The catalog is well illustrated with half-tones and sectional views, giving the reader a clear idea of the interior construction and details of design.

Trade Notes

POWER TURBO BLOWER CO., 17 Battery Place, New York, has been organized for the manufacture of turbo blowers, damper regulators, steam specialties, grate bars and castings. A. N. Hammerstein, for many years vice-president and chief engineer of the Turbo Blower Co., will be the head of the new company, and will devote his experience and engineering knowledge to the service of its customers.

THE UNIVERSAL PORTLAND CEMENT CO. has opened its Duluth plant, known as Mill No. 7, with daily capacity of 4000 bbl. This adjoins the Minnesota Steel Co., from which slag is secured for the cement manufacture. Power comes from the Great Northern Power Co., at Thompson, Minn., 15 mi. distant, 4000 kw. being delivered at 66,000 v., and stepped down to 2200 and 220 for use in the plant.

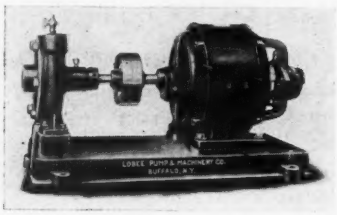
CONSOLIDATED ENGINEERING CO. has acquired all land, buildings and equipment recently owned by the Massachusetts Fan Co., at Watertown, Mass., and has commenced to manufacture at Watertown, the blowers, fans and heating apparatus formerly made by the Massachusetts company.

John E. Anderson, who for 24 yr. past has been a ventilating engineer, and for the last 7 yr. with the B. F. Sturtevant Co., in its Chicago office, has been appointed sales manager in charge of the Massachusetts Blower Department and Kinealy air washer.

In addition to the Watertown equipment, Consolidated Engineering Co. is now erecting in Chicago a new factory, 85 by 233 ft., to be occupied May 1, 1916, which will be concerned with the regular line of Van Auken heating specialties.

STERLING BLOWER CO., of Hartford, Conn., has enlarged its fan business, securing larger and more modern shops, and is in position to supply a complete line of commercial fans. A special engineering department has been organized for the development and manufacture of fans and blowers, and data from years of test and experience have been tabulated and augmented by careful research of the Engineering Department. For turbine drive a special high-speed fan, known as the Equiflo, has been developed, in which the long experience with steam turbine work of W. J. A. London, the works manager, has been embodied.

A COMPACT CENTRIFUGAL pumping outfit shown in the accompanying illustration is manufactured by the Lobee Pump & Machinery Co., of Buffalo, N. Y. for use in buildings where the pressure is low, for the circulation of brine in coolers, and for other purposes of a similar nature.



This is a small iron centrifugal pump fitted with bronze runners to resist the chemical action of the water. It has 1½-in. suction inlet, 1-in. discharge outlet, and a capacity of 25 gal. a min. against a head of 35 ft. When pumping against this head a Westinghouse 1-hp. motor is used. The pump is designed for heads up to 90 ft., but of course in such cases requires correspondingly larger motors.

THE FOLLOWING TABLE gives the number of hours of operation and the percentage of time that generators were in service at the Raritan Copper Works, Perth Amboy, N. J., from August to December, 1915.

Mo.	Total Hrs. in Mo.	Engine Hr. in Operation	No. 1 Per-cent	Engine Hr. in Operation	No. 2 Per-Cent	Engine Hr. in Operation	No. 5 Per-Cent	Engine Hr. in Operation	No. 6 Per-Cent	Percent Total all Engines
Aug.	744	662	89	575.25	77	740.25	99.7	739	99.2	91.5
Sept.	720	719.5	99.9	705.25	98	703	97.6	715	99.4	98.6
Oct.	744	713	96	718	96.5	726.5	97.5	724.5	97.5	97
Nov.	720	691.25	96.1	698	97	696	97	683.6	95.0	96
Dec.	744	732.6	98.5	733.25	98.5	740.5	99.8	742.25	99.9	99
	3672	3518.35	96.0	3429.75	93.4	3606.25	98.5	3604.35	98.2	96.4

The engines are 4-cylinder, triple-expansion, Corliss, size 21, 38, 44 and 44 by 48, driving 900-kw. generators, and were built by the Nordberg Manufacturing Co., Milwaukee, Wis. As noted in the table the engines operated in most cases over 95 per cent of the time, averaging out of the total time in 5 mo., 96.4 per cent continuous operation. The time lost was for the most part in keying up and taking up lost motion in valve gears.

The chief engineer of the Raritan Copper Works is George L. Fales, to whom a large share of the credit for this operating record is due.

A PATENT taken out in Switzerland describes the preparation of tungsten by fusing in an electric furnace, and rapidly cooling with an air blast. It is then exceedingly malleable and ductile.—Electrical Review

PRACTICAL ENGINEER

Trade-mark, Reg. U. S. Pat. Off.

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Full page, one year, each insertion, $60.00.

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Front cover $150.00 per issue.

Other specified positions, regular rate plus 10 to 50 per cent.

Stippled plates used, but no heavy, black and white plates.

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Per line, 30 cents each insertion.

Advertisements in this section are inserted under regular headings.

No display type allowed, but the first three words may be set in capital letters.

About nine words make a line. Minimum space sold, two lines.

Under classification "Position Wanted," advertisements not exceeding four lines will be inserted once for subscribers free of charge.

All copy should be received at Chicago office 18 days before date of publication.

Circulation of this issue, 22,500.

Technical Publishing Co.

537 S. Dearborn Street

Chicago

Position Wanted

POSITION WANTED—As master mechanic or assistant; 21 years' experience. Had charge of erecting, repairing heavy duty engines, machinery and mixed blow turbines. Expert on lubricants. Address Practical Engineer, Box 435, Chicago, Ill. 3-15-1

WANTED—Position as engineer in pumping station or in some stationary plant. I have had 4 years' experience in engineering. What have you to offer? E. W. Adkins, Charleston, Ill. 3-15-1

POSITION WANTED—By chief engineer, 35; married. Use no liquor; 15 years' experience, electrical and refrigeration. Wants position where ability and push will count. Can get results if given opportunity. Practical Engineer, Box 436, Chicago, Ill. 3-15-1

POSITION WANTED—License chief engineer wants change, 12 years' experience in manufacturing and central stations, steam, electrical, refrigeration and producer gas, high speed and Corliss engines, condensers, etc. Age 32, American and married. Address Box 437, Practical Engineer, Chicago, Ill. 3-15-1

POSITION WANTED—By man who has made steam engineering a life study; have had several years' experience; at present am student in Complete Steam Engineering course with I. C. S. Would like position as engineer, assistant or oiler, with reasonable salary to start, and where I can advance according to merits. Age 26. Address Practical Engineers, Box 419, Chicago, Ill. 1-15-2

POSITION WANTED—Chief engineer in a small plant or operator in a large; 12 years' practical experience with steam, electric, refrigerating, pumping and condensing equipment. Technical education. First-class license and references; married, age 31, employed. Practical Engineer, Box 434, Chicago, Ill. 3-15-1

POSITION WANTED—As assistant engineer or oiler. Have had experience in steam, electric and village pumping plants. Other particulars answered by mail. J. G. Wilson, R. D. 2, Bangor, Mich. 3-15-1

POSITION WANTED—Young man wants position as helper and extra engineer in steam plant for a start. Other particulars answered by letter. Write W. D. Bellesfield, Rock Valley, Iowa. 2-1-1

POSITION WANTED—As Chief Engineer. Am qualified to take full charge of power plant, A.C. or D.C., also refrigeration. Age 30. Married. Employed. Chicago only. Address Practical Engineer, Box 421, Chicago, Ill. 2-1-1

POSITION WANTED—As electrician or engineer helper. Thoroughly familiar with electrical motors, wiring and expert meter tester. Four years' experience around steam engines and boilers. Age 23. Reliable. A1 references. Address Practical Engineer, Box 433, Chicago, Ill. 3-15-1

YOUNG MAN, age 26, would like a position as helper in engine room where good advancement is assured. Am I. C. S. student. Will send information. Box 429, Practical Engineer, Chicago. 3-15-1

POSITION WANTED—As Chief Engineer or Manager of produce cold storage plant. Am familiar with gas, oil and steam engine driven plants, also with D.C. light and power of 250 volts. Erecting, repairing and operating. Employed; married, and sober. Will go anywhere. Address Box 428, Practical Engineer, Chicago, Ill. 3-15-1

POSITION WANTED—Inside of power plant by young man with a technical education, but no experience. For particulars write to K. Lufter, Kewaunee, Wis. 3-15-1

Help Wanted

ILLINOIS STATE CIVIL SERVICE COMMISSION—Superintendent of Water Works—On April 1 an examination will be held for this position at various Illinois points. Only one position at the Anna State Hospital is now in existence. Salary, $100 to $150 a month. Open to men over 25 years old. For further information write Illinois State Civil Service Commission at Springfield, Ill., or 904, 130 North Fifth Ave., Chicago, Ill. 3-15-1

FREE ENGINEER BOOKS and power plant tools and specialties for securing new subscribers to Practical Engineer. A dandy chance for the engineer with a little spare time to get some fine premiums. Send for free descriptive circular and terms. Address Practical Engineer, Subscription Department, Chicago, Ill.

WANTED—Resident subscription agents in the following cities: Atlanta, Ga.; Cincinnati and Columbus, Ohio; Kansas City, Mo.; Los Angeles, Cal.; Louisville, Ky.; Newark, N. J.; New Orleans, La.; Portland, Ore.; St. Louis, Mo.; San Francisco, Cal.; Washington, D. C. This is an excellent chance for a hustler, who is familiar with power plant conditions, to turn his spare time into dollars. To such a one we offer a Real Opportunity. Write Subscription Department, Practical Engineer, 537 So. Dearborn St., Chicago. tf.

Wanted

WANTED—Agents handling engine and boiler-room specialties in every section for side line paying large commissions. Give experience, line carried and territory covered. Address Practical Engineer, Box 381, Chicago, Ill. tf.

WANTED—Agents on commission to sell our Shaking Grates. We will install grates on trial or put it on test at our expense with any grate made. Address Armstrong Mfg. Company, Springfield, Ohio. tf.

For Sale

FOR SALE—Stokers; Two new "Crowe" Chain Grate Stokers suitable for 150 to 200 H.P. Boilers. ⅓ original price. Never used. Taken in exchange. The James A. Brady Foundry Company, Chicago, Ill. 2-15-4

Patents and Patent Attorneys

PATENTS THAT PROTECT AND PAY—Advice and books free. Highest references. Best results. Promptness assured. Send sketch or model for search. WATSON E. COLEMAN, Patent Lawyer, 624 F St., N. W., Washington, D. C. tf.

IMPROVEMENTS WANTED—Send for Free Bulletins listing manufacturers' wants and book "Inventions—Patenting and Promoting." Lancaster and Allwine, 292 Ouray Building, Washington, D. C.

PATENTS—C. L. Parker, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. Washington, D. C. tf.

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 606 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had, and the exact costs. Send for full information. tf.

A. P. CONNOR, Consulting Electrical and Mechanical Engineer. Attorney-at-Law and Solicitor of Patents and Trade-Marks. Results guaranteed. 121 Carroll St., S. E. Washington, D. C. tf.-x.

PATENTS—Send sketch for free search and reports. Books on patents and book of reference letters sent free. John S. Duffie & Co., 612 F St., Washington, D. C. tf.

PATENTABLE IDEAS WANTED—Send for three free books. R. B. Owen, 28 Owen Bldg., Washington, D. C. tf.

Technical Books

ENGINEERS AND FIREMEN—Send 10c in stamps for a 40-page pamphlet containing a list of questions asked by an examining board of engineers. Stromberg Publishing Co., 2238-A Pope Ave., St. Louis, Mo. E.O.I-tf.

Miscellaneous

ENGINEERS, DO YOU WANT to utilize your exhaust steam for heating or drying purposes, without back pressure on your engine? If so, address Monash Engineering Co., 1413 W. Jackson Blvd., Chicago, Ill.

Sparks From The Advertising Pages

This issue we devote this page to the publication of three letters that have recently come into the office. (Names of writers furnished on request.)

Practical Engineer,
Chicago, Ill.
Gentlemen:
"Do not want to miss a copy—the ads are worth more than the price of subscription."

This comes from a Chief Engineer who has found the advertising pages a source of direct help to him. In his official capacity he has found it necessary to read the advertising section studiously so that he may keep posted on the new things continually being invented and developed. To him, the advertising pages are "the stamp of approval" on any device represented therein—a trust that is guarded by the publishers of Practical Engineer with infinite care.

If men who have already "arrived" find it necessary to study carefully this advert sing section, how much more indispensable it must be to the engineer with aspirations and hopes.

Practical Engineer,
Chicago, Ill.
Gentlemen:
"Having been in the engineering game only 52 years, and trying to learn more about it every day, I need Practical Engineer even as I need my meals and JUST AS REGULARLY."

That's putting it pretty strong, but ever notice how engineers have a natural propensity for driv ng home the truth in a quaint and unmistakably frank manner—homespun philosophy is the engineer's natural trait. This man who is also a Chief Engineer could have gone a step farther and said—"It is the means of assuring me 'three squares' a day because it has helped me to improve myself and to grow with the times and establish a permanent place in my organization."

Practical Engineer,
Chicago, Ill.
Gentlemen:
"I am leaving here for Detroit, Mich., in a couple of days, so please send my Practical Engineer to my new address.
I am taking all my old numbers with me; it will cost about $10.00, *but I have got to have them."*

Most engineers keep every issue of Practical Engineer so the above is not a rare instance. Back files are important and it is a good plan to have both editorial and advertising sections bound up in book fashion. Keeps them together, costs but a trifle, and is a valuable reference work.

We have received many other letters equally as interesting as the above, but have selected these at random. They emphasize the importance of reading thoroughly every issue of Practical Engineer—both advertising and editorial pages which combine to make a publication that is valuable as a medium of information and as a safe and satisfactory buying guide.